Deltares

Technische Universität Darmstadt
Institut für Arbeitswissenschaft

Master Thesis

Stakeholder oriented optimization of a Flood Warning System

Stakeholder-orientierte Optimierung eines Flutwarnsystems

Laura Basco Carrera

2013

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14.05.2013

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Abstract

This MSc Thesis is part of the Project "Desarrollo e Implementación del SAT-Beni". The project aims to minimize the adverse effects of floods in the region of Beni through the development and implementation of an Early Warning System based on modelling and hydrologic simulation and transferring these technologies to the appropriate Bolivian institutions. The specific objective of this MSc Thesis is to provide some specifications for improvements to the existing flood Early Warning System based on the interest and needs of the stakeholders involved as identified by themselves and that are feasible with the available technology. Monitoring and forecasting acquire significant relevance within the new Early Warning System that will be developed and implemented in the region of Beni. However, the development of the new flood Early Warning System does also consider as relevant the warning dissemination and communication, as well as, the emergency preparation and response.

The research was carried out using data collected during Interviews with experts and inhabitants who have experience of floods in the region. A review of literature on the topic was made and discussions with Deltares staff were held to analyze the existing flood Early Warning System. Field research shows a variety of optimal lead times at which forecasts are required. Stakeholders considered to be relevant in the analysis as their different needs will impact on the design of the future warning system include: disaster management agencies, national and local governments, businesses, inhabitants local to the area studied and disadvantaged minorities. Whilst studying the existing system important lacks in the monitoring network in terms of O&M, personnel, equipment and coordination have been identified. The warning information dissemination network includes several organizations and various communication technologies which are

used to warn, such as radio, TV, mobile and conventional phones, door knocking, etc. However, due to a huge number of people who do not receive any warning information, loudhailers and sirens need to be encouraged. Results of the research confirm that the effectiveness of warning messages depends on a large number of factors including accuracy, reliability, credibility, that they reach the right target recipients and that they are timely. In addition the individual and agency that disseminates the warning has a tremendous impact on the success of the message. In terms of flood responses, saving family members, household goods and livestock are the main activities carried out by ranchers and citizens. Farmers, however, frequently do not take any preventative action in order to save their crops. Risk awareness which includes the visibility of floods and prior experience has been identified as the main factor that influences the type of flood response taken and people's perceptions of imminent danger.

Key words: Stakeholders involvement, floods, early warning systems, warning, emergency communications

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1. Introduction

Bolivia is characterized by its relatively strong climate variability directly related to the phenomena of 'El Niño' and 'La Niña'. Unfortunately, climate change has a notable influence as it can increase this variability. As a result, 'El Niño' and 'La Niña' occur over shorter periods and climatic events are becoming more extreme[1]. National statistics confirm that natural hazards, especially climate hazards, affect greater number of victims. This is the case of Beni, one of the departments (provinces) of Bolivia. Based on the agro-ecology conditions of this region, extensive farming is the main economic activity. As a result, these climatic phenomena and their direct consequences also have a dramatic impact on the economy of the region; which are due to the extent of losses of ecosystems, biodiversity and environmental services. The use of an Early Warning System is assumed to be the best cost-effective non-structural alternative to mitigate the vulnerability of the flood hazard areas in Beni.

The Plurinational State of Bolivia is located in central South America. As it can be seen in Figure 1, Bolivia is bordered by Peru to the west, Chile to the southwest, Argentina and Paraguay to the south and Brazil to the east and north. It is divided into nine departments, Pando, La Paz, Beni, Santa Cruz, Cochabamba, Oruro, Potosí, Chuquisaca and Tarija. The national capital is called La Paz and is located in the department of La Paz.

According to the UNDP[2], Bolivia is currently (2011) ranked 108th out of 187 countries in the Human Development Index (HDI) ranking, which is included in the Medium Human Development

[1] VRHyR, 2010

[2] UNDP, 2011

range. The Gross National Income per capita in 2011 is US$ 4054. In comparison with the other Latin American and Caribbean countries, Bolivia is one of the least developed.

In terms of demographics, according to the Bolivian National Statistics Institute, the estimated population in Bolivia was around 10,5 million in 2010, 66,4% of which was concentrated in urban areas. Although Spanish is the most spoken language, due to the great diversity of cultures, another 36 official languages are recognized including, amongst others, Moré, Aymara, Guaraní, Mojeño-trinitario and Quechua.

Figure 1: Political map of Bolivia[3]

[3] UN, 2004

The El Niño–Southern Oscillation phenomenon[4] is a complex interaction of the tropical Pacific Ocean and the global atmosphere that results in irregularly occurring episodes of changed ocean and weather patterns in many parts of the world, often with significant impacts over many months, such as floods and droughts. The ENSO (El Niño–Southern Oscillation) phenomenon refers to the well-above-average ocean temperatures that occur along the coast of Ecuador, Peru and northern Chile and across the eastern equatorial Pacific Ocean, while La Niña part refers to the opposite circumstances when well-bellow-average ocean temperatures occur. The Southern Oscillation refers to the accompanying changes in the global air pressure patterns that are associated with the changed weather patterns experienced in different parts of the world.

The project "*Desarrollo e implementación del SAT-Beni*" focuses on the floodplains of the Mamoré river in the department of Beni, which is tributary of the Amazon river. Within this study region, a more detailed study will be made of the flood vulnerability and flood hazard mapping of three pilot municipalities, Santa Ana de Yucuma, San Ignacio de Moxos and Loreto which are located in the middle and lower basin of river Mamoré. However, although the direct beneficiaries are the three municipalities, another seven municipalities will also benefit from the project. These indirect municipalities are: Trinidad, San Javier, San Andrés, San Joaquín, Exaltación, Puerto Siles and Guayaramerin. The research described in this report has been carried out in the framework of this project.

[4] UNISDR, 2009

Figure 2: Mamoré river basin

The department of Beni is located in the northeast of Bolivia in the Llanos region (see Figure 1). After Santa Cruz, it is the second largest department in the country. Most of the region has an altitude of 155 meters (ASL). According to Bolivian National Statistics Institute, the estimated population in Beni in 2010 was around 450.000. The population that will benefit directly and indirectly from the new flood EWS accounts for around 224.990 people.

It must be noted that the indigenous population living in this department is approx. 100.000, which accounts for 22% of the total population in Beni. Approximately 290 indigenous communities live in the middle basin of River Mamoré. At least 200 communities are located in the study area of the project, including the ethnic groups *Mojeños*, *Caimanes* y *Yuracarés* in Loreto and San Ignacio de Moxos and *Movinas* and *Cayubabas* in Santa Ana del Yacuma. The largest concentration of indigenous communities is located in the province Moxos (90 communities).

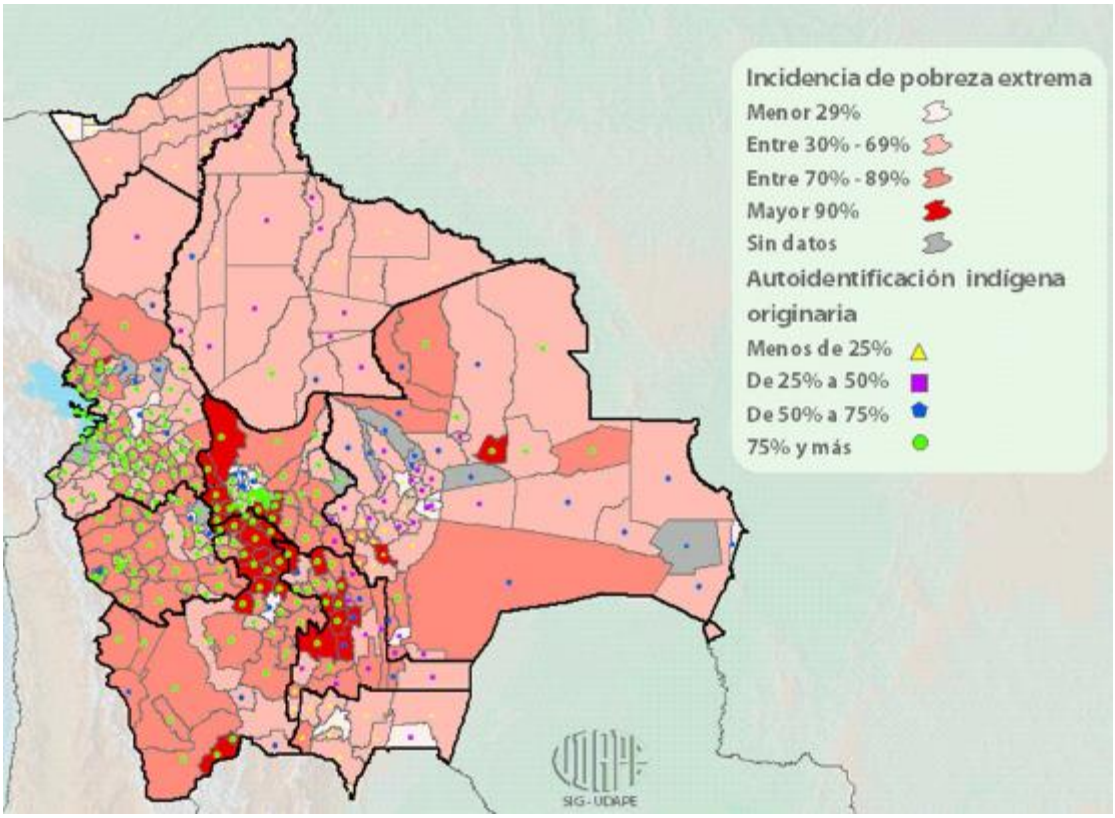

Figure 3: Rate of extreme poverty and indigenous ethnics in Bolivia[5]

Due to the fact that San Ignacio de Moxos, Santa Ana del Yacuma and Loreto are the direct beneficiaries of the project, their demographic characteristics are analysed in more detail in Table 1. Data have been sourced from the Bolivian National Statistics Institute (2001)[6]. These three municipalities have a high index of unsatisfied basic needs (NBI), specially San Ignacio de Moxos (92,5%) and Loreto (96,4%). This index measures poverty based on basic needs. In the case of Bolivia the basic needs indicators are nine: housing, exclusion, safe water, sanitation-toilet, school attendance, illiteracy, health and social security and electricity. Excluding Santa Ana del Yacuma, the other two municipalities can be considered as rural areas. In general terms, and based on comparative demographic data, it can be concluded that Loreto is in worse

[5] www.climateinvestmentfunds.org

[6] VRHyR, 2010

demographic situation than San Ignacio de Moxos and Santa Ana del Yacuma.

Municipalities	San Ignacio de Moxos	Santa Ana del Yacuma	Loreto
HDI rank	0,59	0,62	0,56
Poverty NBI (%)	92,5	68,3	96,4
Per capita consumption (US$/y)	911	1.069	910
Life expectancy at birth (y)	63,6	67	60,5
Percentage of rural population (%)	59	31	100
Education index	0,68	0,7	0,67
Net enrolment rate (y)	5,6	7,0	4,9
Adult literacy rate (%)	82	90,3	82

Table 1: Demographic aspects from the direct municipalities benefited

The Beni lowlands have a tropical climate. Due to the movements of masses of air charged with humidity from the northeast of the Amazons and from the Atlantic, the summer (ITCZ), from November to May, is the rainy season, characterized by its abundant precipitation (over 300 mm/month)[7]. During the winter season, from June to November, the weather is cooler and drier and winds blowing northward from the South cause a decrease in temperatures. Although, the department of Beni, as the Bolivia country in general, is characterized by relatively strong inter-annual climate variability related to the phenomena of 'El Niño' and 'La Niña', in the last two decades the duration of these phenomena have become shorter and their impacts stronger.

The primary economic activity and land use practice in Beni is ranching, particularly extensive livestock farming, which is due to the agro-ecology conditions of the region. Economic activity is largely concentrated in the middle basin of River

[7] VRHyR, 2010

Mamoré, accounting for 40% of livestock in the whole department of Beni (1,1 millions livestock). Currently 3000 livestock production units are located in the middle basin of the River Mamoré, being 2000 small-scale livestock producers who are the most vulnerable to natural disasters such as flooding. Moreover, 1200 of the small-scale livestock producers own less than 100 animals. For these producers, ranching is a secondary economic activity, mostly intended for home and community consumption. The main crops that they produce, amongst others, are rice, maize, yucca roots, citrus fruits and banana, mostly destined for local markets and self-consumption. Their agricultural areas are usually up to 3 ha./producer. Fishing and hunting are additional economic activities that complement their economy. The economy of the region is rather weak and vulnerable due to the following circumstances:

- dependence on a single product (meat)
- final destination of goods outside the region, where the customer is located and
- the lack of economic and trade integration with rest of the department and the country

The local economy does not show significant dynamic regional economic development either.

Figure 4: Cattle farms in Beni

This Thesis reports the settings and results of the MSc research. In chapter 2 the specific goal of the research and the research questions are presented. The analysis of the problem in the department of Beni and an introduction of the issue of disaster risk management is carried out in Chapter 3. The methodology of Early Warning Systems explained in chapter 4 includes an analysis of the components and types of EWS, a description of the main activities and data gathering methods used in the research and the specification of the limitations encountered. A stakeholder analysis including the identification of the interests and needs of the relevant stakeholders is carried out in chapter 5. This chapter is followed by the assessment of the existing flood EWS in Beni and other departments including the main strengths and weaknesses of these warning systems. Chapter 6 also makes some recommendations considering the interests and needs of the main stakeholders. Finally, Chapter 7 exposes the conclusions of the MSc research.

2. Goal and Research questions

2.1. Goal

The goal of this research is to specify possible improvements to the existing flood Early Warning System in Bolivia based on a multi-level stakeholder involved approach. In order to achieve this purpose, the interests and needs of the stakeholders involved in the existing flood Early Warning System and other stakeholders considered relevant to the new Early Warning System are considered.

2.2. Research questions

- *Who are the stakeholders and what are their specific roles within the field of flood Early Warning Systems in Beni?*

- *What are the interests and needs of each stakeholder involved?*

- *What are the strengths and weaknesses of the existing Early Warning System?*

- *What are the recommendations for the design and implementation of the new flood Early Warning System considering the needs of stakeholders?*

The first two research questions are addressed in Chapter 5 while the last two are addressed in Chapter 6.

3. Problem analysis and disaster risk management

This chapter aims to make a brief analysis of the current situation in Bolivia focusing on the dramatic effects of natural disasters that have occurred in the Beni department during the last few decades. An effective flood EWS has been considered as the most cost-effective solution in the short and middle term to mitigate flood damage. The presentation of current disaster management, including the global trend of natural disasters occurring during the last decades is rigorously described in order to establish a solid background to the extended description of EWS, which is carried out in the following chapters.

In the next subchapter a brief description is given of the geographic and economic position of Bolivia. The analysis includes the study case of the Beni department, the region where the project "*Desarrollo e implementación del SAT-Beni*" is implemented. The description is based on analysing the historical data of natural disasters occurring in Bolivia with their devastating consequences.

3.1. Problem analysis

Bolivia has experienced 70 registered natural disasters since 1975, including floods, droughts, wildfire, amongst others. According to the EM-DAT database[8], the trend during the last four decades shows a considerable increase in the number of natural disasters per year. The average number of disasters up to 1990 was one per year, whereas, after 1990 the average has increased into three natural disasters. It can be appreciated therefore in Figure 5 that flooding is the main natural disaster in Bolivia, accounting for an average of 41% of the total number of disasters since 1975. Drought is the second

[8] EM-DAT, 2012

main natural disaster followed by epidemic with percentages of 17% and 14%, respectively.

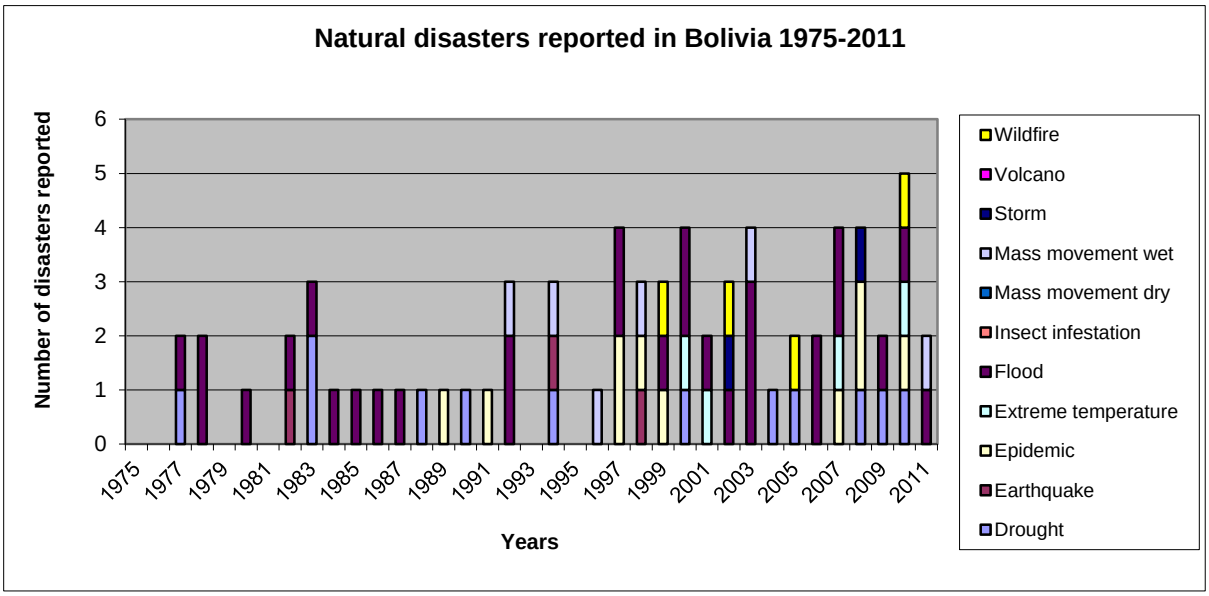

Figure 5: Natural disasters reported in Bolivia 1975-2011

The number of people affected by flooding has increased in the recent years, reaching a maximum in 2001. Although in 2001 there was only one flood disaster, it caused the highest flood damage since 1975, affecting 357.250 people. On the other hand, the reported death toll was lower than in other years (40 people). The maximum death toll caused by flooding was in 1983 when 250 people died. A trend analysis shows that the death toll decreased drastically after 1983; however, after 1997 it has increased considerably, accounting for an accumulated number of 394 victims between 1997 and 2011. This higher number of deaths can be related to the fact that the number of flooding disasters and, natural disasters in general, have increased considerably in recent years.

According to BID[9], ranching generates between US$50 and US$60 million annually. The estimated damage caused by these phenomena reaches up to 35% of the production, reaching US$20 million when an extreme event occurs. On the other hand, when

[9] VRHyR, 2010

"normal" events occur, the estimated damages account for US$8-10 million. In the case of Beni, the frequency of the Mamoré river flooding has dramatically increased during the last few decades. Historical data since 1784 show that the period between events ranged between 2 and 14 years, this then increased to a frequency of 18 events last 100 years and this has increased in the last few years.

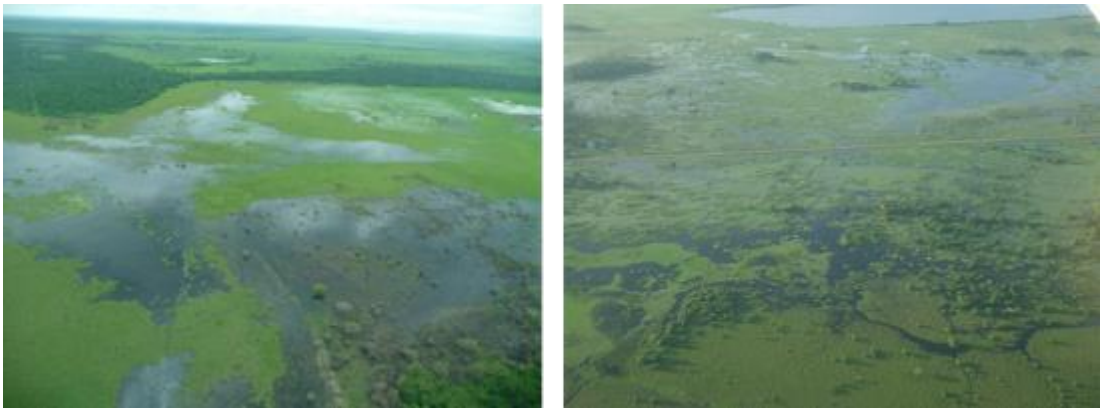

Figure 6: Beni landscape and flooding

The weakness and vulnerability of the economy in Beni is caused partly by the frequent economic damage as result of both phenomena El Niño and La Niña. Table 2 records the impacts caused by the recent phenomena in the Beni region. With the exception of the phenomena during 2002 and 2003, all other phenomena caused considerable damage in terms of livestock killed and people affected by the disasters. While the total estimated damage caused by El Niño and La Niña in 2006 – 2007 amount to US$ 440 million, one year later, in 2007 and 2008, this amount increased to US$ 520 million. These figures confirm the nationally upward trend of people affected by natural disasters, particularly by flooding. These figures also point to the fact that the economic impact of these phenomena has also increased in recent years. It should be mentioned, though, that these statistics do not reflect the huge number of poor people whose lives are indirectly disrupted by the economic impact of natural disasters. The effect of natural disasters on the poor is that the ability to

raise a modest income is reduced and the prospect of escaping poverty is thus postponed.

Year	Intensity	Affected areas	Duration (months)	Damages
1992 / 1993	Strong	Beni department	7	Livestock killed: 200.000 Families displaced: 8.000
1997 / 1998	Moderate / Strong	Itenez province	3-4	Livestock killed: N.A. Families displaced: 25.000
2002 / 2003	Moderate	Marbán province	2	Livestock killed: 10.000 Families displaced: N.A.
2006 / 2007	Strong	Mamoré middle basin	5	Livestock killed: 178.000 Families displaced: 133.000
2007 / 2008	Strong	Mamoré middle and lower basin	4	Livestock killed: N.A. Families displaced: 120.000

Table 2: Characteristics of El Niño and La Niña in Beni 1992-2008

The design and the implementation of EWS has been the most cost-effective solution considered by Bolivian organizations and others to mitigate the effects of these natural disasters. DGR and SEMENA have been responsible for the development of the current EWS. Unfortunately, due to the limitations of the national EWS, the impact of natural disasters, particularly the floods in the Llanos region, on Bolivia is devastating and is severely undermining development and poverty eradication efforts.

3.2. Disaster Risk Management

A disaster is defined by UNISDR[10] as a serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental losses, which exceed the ability of the affected community or society to cope using its own resources. A disaster arises from the combination of the hazard event or episode, the conditions of vulnerability to that hazard and the insufficiency of capacity or measures to cope with the hazard.

According to the statistics of reported disaster data (EM-DAT[11]), the global trend over the last four decades shows a considerable increase in the number of natural disasters (floods, droughts, wildfires, etc.) and an increase in the number of people affected by these natural disasters. Disaster impacts have an upward trend as a result of the combination of increasing populations, greater concentrations of people and the placing of assets in vulnerable areas, modification and degradation of natural environments, for instance, soil erosion, deforestation, river channeling and land fertility decline. On the other hand, vulnerability to hazards is aggravated by poverty, conflict, diseases and population displacement.

Figure 7 reports that the number of natural disasters has more than tripled since 1975 in the world; however, it can be appreciated that there has been a slight reduction in recent years. In terms of the number of people affected by natural disasters, the trend shows an increase but there is huge variation between years. Although the reported number of people killed by natural disasters has halved since 1975, there is also a significant variation between years.

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[10] UNISDR, 2009

[11] EM-DAT, 2012

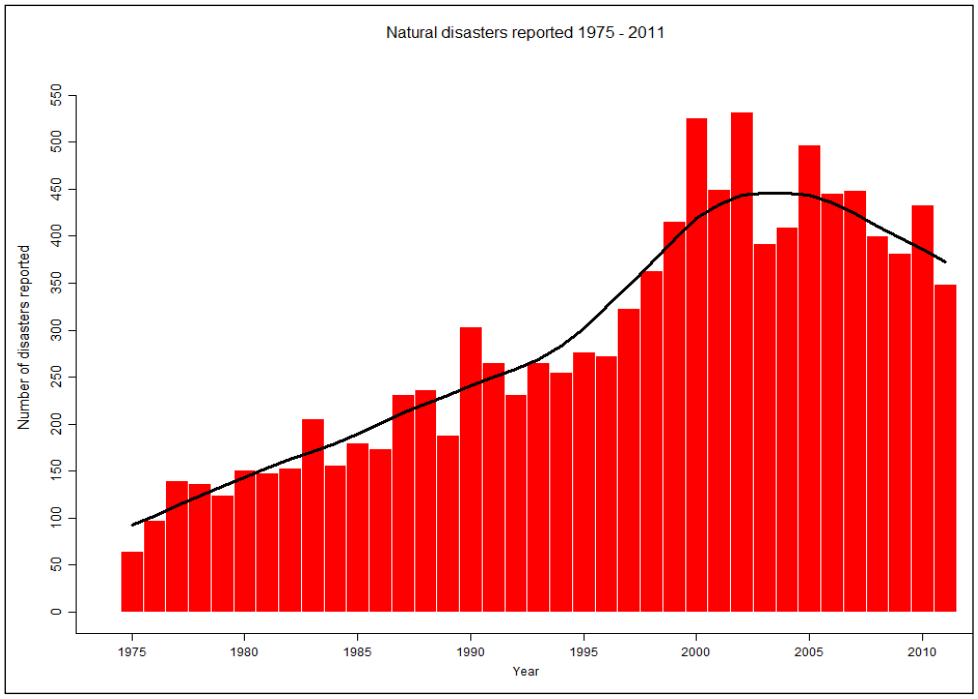

Figure 7: Natural disasters worldwide 1975-2011

The definition of a flood as used by the World Bank[12] is "*An overflowing or irruption of a great body of water over land in a built up area not usually submerged*". These natural disasters are the most destructive events in terms of lives and damage losses. In Bolivia, it is now increasingly accepted that flood risk cannot be eliminated. However, disaster risk management activities can reduce the likelihood of flood events and can reduce the impact of floods.

Due to the fact that disaster occurs when hazards and vulnerability meet, defining these components is crucial to the basic understanding of disaster management. According to UNISDR[13] a **hazard** can be defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. It is important to note that hazards are

[12] Jha A., Bloch R. and Lamond J., 2011

[13] UNISDR, 2009

dynamic and with highly varying potential impacts. Hazards can be classified into natural disasters or manmade disasters. Due to the fact that this MSc Thesis focuses on natural disasters, manmade disasters are not further described.

Natural hazards can be divided into three broad categories: hydrometeorological, geological and biological. Worldwide, hydrometeorological hazards are most common and floods alone account for two-thirds of people affected by natural hazards. Hydrometeorological hazards are defined by UNISDR as natural processes or phenomena of atmospheric, hydrological or oceanographic nature. Some examples are floods, droughts, temperature extremes, tropical cyclones, etc.

Vulnerability is a reflection of the state of the individual and collective physical, economic, environmental and social conditions at hand. These are shaped continually by attitudes, behavior and cultural, socio-economic and political influences on individuals, families, communities and countries. Vulnerabilities can be classified into physical, socio-economic and environmental vulnerability[14].

Physical vulnerability can be described as a natural disaster but is only a disaster because people are in the wrong place at the wrong time and had no choice but to be in the way of a disaster or were caught unawares when it struck. It can be determined by aspects such as population density levels, remoteness of a community, the site or design and materials used for critical infrastructure and housing, etc.

Economic status, reserves, levels of debt and the degree of access to credit, loans and insurance for individuals, communities and nations establish the level of economic vulnerability. Generally, the poor are far more vulnerable than economically better off segments of society. As a result,

[14] UNISDR, 2004

the probability of proportional losses when a disaster occurs is higher among the poor. Moreover, poorer people tend to have a more limited capacity to recover from disasters.

Social-economic vulnerability is further divided into economic and social vulnerability. Vulnerability can be determined by aspects related to levels of literacy and education, the existence of peace and security, access to basic human rights, systems of good governance, social equity, positive traditional values, customs and ideological beliefs, and overall collective organizational systems. Institutional organizations and their governance structures also play an important role in levels of social vulnerability. Generally, people less privileged in class or caste structures, ethnic minorities, young and old people, women, disabled and other disadvantaged and marginalized segments of the population are more vulnerable. Traditional knowledge systems and some cultural aspects, for instance, indigenous beliefs and traditions are decisive factors in people's perception of risk. Finally, environmental vulnerability includes aspects such as extent of natural resource depletion, the state of resource degradation, a lack of resilience within ecological systems and exposure to toxic and hazardous pollutants.

Risk is defined by UNISDR as the probability of harmful consequences, or expected loses (deaths, injuries, loss of property, livelihood, disruption of economic activity or damaged environments) resulting from interaction between natural or human-induced hazards and vulnerable conditions. Risk is a function of both hazard and vulnerability.

The mathematical form of defining Flood Risk is by multiplying the probability that a potentially damaging event occurs by the expected damage due to the event[15].

[15] Werner M., 2012

$$FloodRisk = \int_0^1 p(E)D(E)dp$$

Equation 1

Where:

p(E): Probability of event E occurring

D(E): Expected damage because of event E

However, the most common terms used to define flood risk are hazard and vulnerability as shown in the equation:

$$FloodRisk = hazard \cdot vulneravility$$

Equation 2

As a result, risk analysis involves hazard and vulnerability assessments. While hazard evaluation frequently requires the knowledge of technicians, for monitoring and storing data of geological and atmospheric conditions; vulnerability assessment make use of community-based methods, for instance, risk maps, in order to involve the community in the risk analysis.

Disaster management includes the combination of all activities, programs and measures that can be carried out before, during and after a disaster occurs with the purpose of avoiding the disaster, reduce its impact or recover from it. The disaster management cycle establishes the various stages followed before, during and after a disaster. Figure 8 displays the variant of disaster management cycle defined by IHE-UNESCO.

Pre-disaster initiatives are classified into prevention and mitigation. These include structural measures, including dykes and channel measures, amongst others, and non-structural measures, for instance, spatial planning, flood protection, vulnerability and risk assessments.

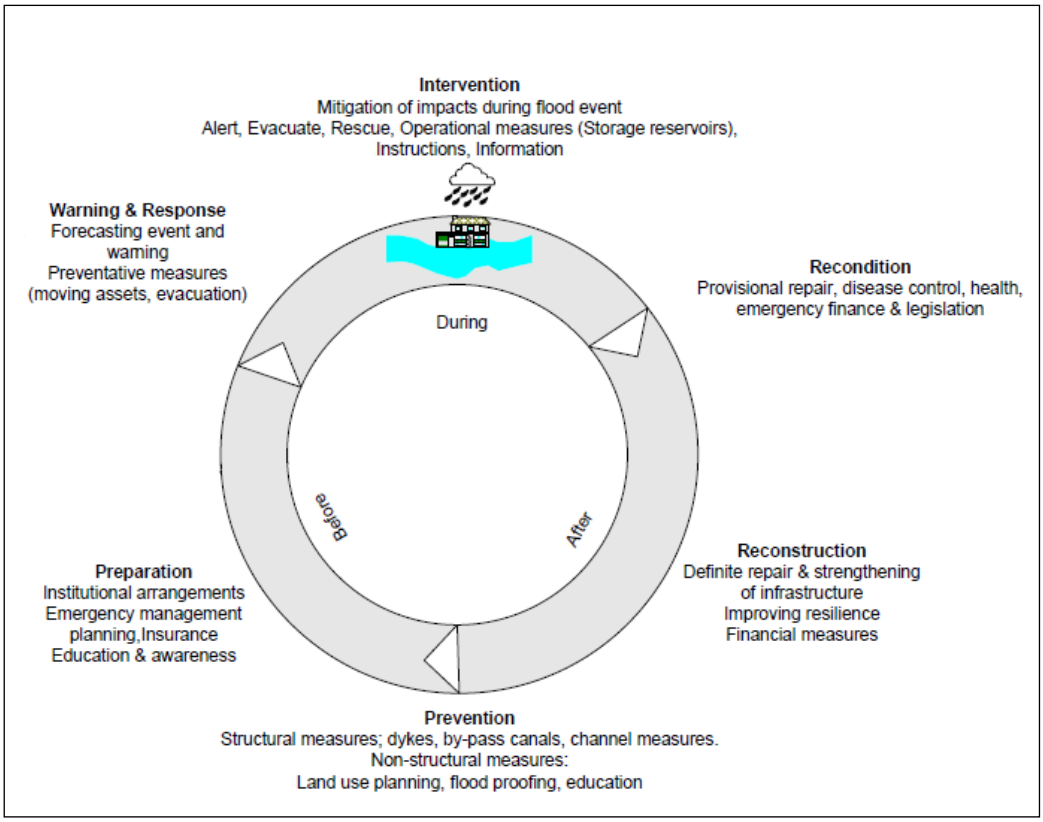

Figure 8: Disaster management cycle[16]

Early warnings, risk communication together with emergency management and evacuation plans are activities included in preparedness in the short term. All these activities are taken to reduce human and property losses caused by a potential hazard. Moreover, during a disaster some initiatives are taken to ensure that the needs of victims are met, provisions found and suffering are minimized. Warning, evacuations, rescue, operational measures (e.g. storage reservoirs) and emergency aid are some of the initiatives that establish intervention and are worldwide known as emergency response activities.

Post-disaster activities are taken in response to a disaster in order to achieve early recovery and rehabilitation of affected communities. These are called response and recovery activities. Damage and needs assessments, restoration and reconstruction are part of these post-disaster activities.

[16] Werner M., undated

Based on the premise that the development and implementation of a EWS is the most cost-effective option to minimize the adverse effects of floods in the region of Beni, this non-structural prevention measure is extensively described in this report.

The project "*Desarrollo e implementación del SAT-Beni*" aims to shift disaster management towards disaster preparedness. It intends to contribute towards the change of the current reactive approach into a proactive approach in this field. An information system in disaster risk management should help to identify needs and interests of stakeholders as well as to monitor and organize the inflows and distribution of response and assistance aid from NGOs, governments and other organizations. Therefore, flood early warnings, as part of disaster preparedness, are recognized as a relevant strategy in flood risk management. However, flood early warnings are only effective if disaster reduction is emphasized. The emergence of a disaster reduction culture depends on the following context and processes[17]:

- Political context
- Sustainable development in its three related contexts: socio-cultural, economic and environmental
- Regional considerations linking disaster reduction and sustainable development

In terms of political context, it should be taken into account that the design and implementation of an EWS depends to a large extent on the amount of political will. According to a study of the Flood Early Warning System in Mozambique[18], whose disaster risk management has been acknowledged by the World Bank for its efficient preparedness and contingency planning, it was reported that "… *most things in the country do not work out if politicians do not accept these things as their*

[17] UNISDR, 2004

[18] Klingberg P., 2011

problems... I believe that's why we have this success story [Early Warning System], because the government has been involved". It must be considered that generally in the short term the level of political will at national and municipal level is relative high. Unfortunately, in some cases, support starts to decrease gradually after a period of time. In order to achieve yielding long term effectiveness, strong political and institutional capacities that appreciate the potential benefits of the implementation of an EWS are crucial[19]. Unfortunately, these required political capacities are often unattainable in the short and middle term in developing countries.

The effectiveness of every project within the field of disaster management has a great dependence on sustainability not only in the short term but also in the middle and long term. The concept of sustainability is based on three pillars: social equality, economic efficiency and environmental integrity. Although these three pillars should be mutually supportive, a conflict between them can occur. Hence, management for sustainability is a complex task that involves continuous negotiation and compromise, economic optimization and maintenance of social justice, and considering environmental integrity as crucial[20].

Socio-cultural context

As a pillar of sustainable development, the link between disaster and the socio-cultural system is an important component in disaster risk reduction. A disaster reduction strategy must be built on sustainable development policies, which consider potential risks and the plans to reduce their effects; involving people and providing not only help but hope. Disaster reduction[21] activities need to be based on more

[19] Basher R., 2006

[20] Jha A., Bloch R. and Lamond J., 2011

[21] UNISDR, 2004

attentive participatory approaches involving local communities, considering them as proactive stakeholders and not passive targets for intervention. Political commitment is an essential ingredient for sustained risk reduction efforts. Disaster risk reduction should be dealt with as a policy issue across relevant fields of government including health, agriculture, environment and development. However, although political support for disaster risk reduction has to be established from the apex of political power, it is only realistic if the perceptions of risk and the actions proposed for risk minimization accord with the cultural beliefs and habits of society

Finally, cultural patterns which structure the lives of women and men also must be clearly understood. Their differing needs, roles and social power in various social contexts need to be considered. Men are usually seen as primary income generators while women's economic activities, often the mainstay of the household economy, are less visible. Women assume primary responsibility for the care of children, the elderly, the disabled and the ill whose mobility and survival in disasters may be limited. It should be mentioned that women's roles, as primary resource users and managers, make them essential partners in wise environmental management to reduce risk. They can be especially proactive in risk reduction initiatives at the household and local levels. As a result, gender-specific dependencies and vulnerabilities are relevant in disasters as is the respective ability of women and men to participate fully in household, community and national decision-making about hazard and risk management

Economic context

Another pillar of sustainable development is the economic system, which is closely linked with disaster. Risk management planning[22] involves an estimation of the impacts of potential

[22] UNISDR, 2004

disasters on the economy, based on the best available hazard maps and macroeconomic data. These include assessments of the costs associated with disasters, a cost/benefit analysis of disaster reduction and risk transfer measures (including the value of improved forecasting systems) and incentives from the international community that lead towards proactive disaster reduction projects. According to the South Pacific Reduction Project (1997), the actual dollar value of disaster loss is probably not the most relevant parameter, but rather the cost to the particular nation in terms of percentage of GDP, which can be very significant indeed. The study noted that, countries with limited economic diversification, combined with a high agriculture and GDP ratio are particularly exposed to disaster devastation and considerable economic loss. In the short to medium term, the destruction of standing crops and the loss of physical infrastructure and housing could be severe, with the consequence that GDP could become sharply depressed for some time, with the likely consequence of provoking macroeconomic instability.

Environmental context

The environmental system[23] is another pillar of sustainable development. Disasters do not only affect the socio-economic environment but also the natural environment. Environmental degradation increases the intensity of natural hazards and is often the factor that transforms the hazard into a disaster. The natural environment provides solutions to increase protection against disaster impacts. Hence, successful disaster reduction should enhance environmental quality, which includes:

- Protection of natural resources and open space
- Management of water run-off
- Reduction of pollution

[23] UNISDR, 2004

4. Early Warning Systems and methodologic approach research

This chapter aims to make a brief introduction of Early Warning Systems for disasters including the different types and components of the warning chain. Moreover, the methodological approach of the research, in particular the data gathering methods are specified according to the specific goal of each research question. Finally, limitations encountered during the preparation of this MSc Thesis are presented in this chapter.

4.1. Types and components of Early Warning Systems analysis

The definition of an Early Warning System includes some variations because of the scientific disagreements in the research field. The UN defines the EWS as the provision of timely and effective information, through identifying institutions, that allow individuals exposed to a hazard to take action, to avoid or reduce their risk and prepare for effective response. Although there are various definitions of EWS, at the heart of all EWS is some sort of model that describes the relevant features of the hazard phenomenon and its impacts, particularly their time evolution. This has the purpose of increasing safety and minimizing the harmful effects of floods such as human casualties and other losses or damage. Despite the considerable range of definitions and concepts, an Early Warning System must be viewed not simply as a technology, but rather as a unified system made up of five critical and inter-related issues[24]:

- Hazard identification, risk and vulnerability analysis
- Detection and monitoring
- Emergency management structure
- Local warning dissemination
- Public education

[24] Anderson P., 2006

Furthermore, an effective Early Warning System also must provide information about how to prevent and mitigate disasters and provide information and knowledge to aid timely response.

The elements of the warning chain established by Carsell (2004)[25] and Werner (2011)[26] are considered in this MSc Thesis as the most appropriate for the implementation in the region in Beni. It consists of six activities that follow the natural course of events when they start and the likelihood of a natural disaster is high, which means that the implementation of a EWS has already been carried out. The term used to define this concept is 'end-to-end' warning system, hence, weakness or failure of any element of the EWS can cause the failure of the whole system.

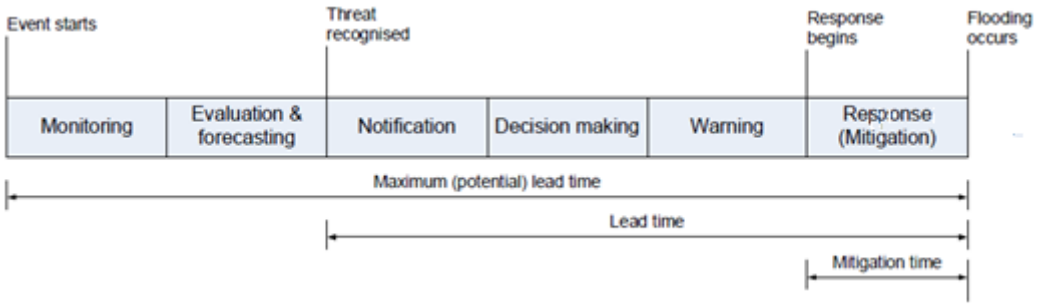

Figure 9: Elements of the warning chain of Carsell 2004 (after Werner 2011)

When an event starts, information need to be gathered through monitoring networks and communication systems so that forecasters are able to recognize the occurrence of the event. In order to achieve this, some time is required to analyze the obtained data and perhaps to run one or more hydrological models, so that some guidance on future evolution of the model can be provided. In the case that the threat is recognizable, it needs to be communicated to the decision makers. After taking the considered appropriate decisions for example issuing a warning, users initiate the pertinent response. It is perhaps obvious to say that any action, such as evacuation

[25] Carsell, K.M. Pingel N.D. and Ford D.T., 2004

[26] Werner M., Winsemius H.C. and Robinson B., 2011

of affected villages, should be completed prior to inundation by flood levels. This methodology is useful for identifying lead times and the accuracy needs of different stakeholders. A brief description of the elements that establish the warning chain is detailed below:

Monitoring: Systems with an operative and effective monitoring network together with an efficient communication system allows access to data periodically.

Evaluation and Forecasting: Predicting capacities provide timely estimates of the potential risk faced by communities, economies and the environment.

Notification: Good interinstitutional relations together with an efficient communication system allow a proper coordination between technicians and decision makers.

Decision making: Deciding the most appropriate actions and measures at the right time considerably increases the likelihood of success and thus, the reduction of damage.

Warning: An efficient communication system is needed for delivering warning messages to the potentially affected locations to alert local and regional governmental agencies. The messages need to be reliable and simple to be understood by authorities and public.

Response: Coordination, good governance and appropriate action plans are a key point in effective Early Warning. Likewise, public awareness and education are critical aspects of disaster mitigation. Also risk knowledge plays a decisive role in EWS. Risk assessment provides essential information for setting priorities for mitigation and prevention strategies and for designing Early Warning Systems.

The most common type of EWS is a warning chain based only on a linear set of connections from observations through warning generation and communication to users. In this system, the flow of information is one-way and the users can make no more than a restricted definition of their needs. Based on these observations, the optimal EWS should consider that each

element interacts with each of the other elements. Thus, it should establish a dialogue with the stakeholders, including citizens, instead of one-sided provision of information from elements above.

The extent of losses avoided as a result of a warning is a key measure of EWS effectiveness[27]. The effectiveness of the system depends largely on the availability and quality of required data and on the model per se combined with warning and communication methods and with the use of the information provided in taking timely response actions to a possible natural disaster by the community at risk. Since the EWS is conditioned by the specific context of the region, its effectiveness depends largely on whether local conditions of the area have been considered when designing and implementing the EWS.

To date, the most common type of EWS used worldwide is the linear model which emphasizes the hazard itself. The institution/s responsible for designing and implementing the warning system puts focus on monitoring and forecasting. Scientists and technologists are then the main stakeholders in the EWS, as they have in their possession the geophysical and technical knowledge base. As a result, EWS tend to be largely conceived as hazard-focused, top-down, expert driven systems. However, centralized flood EWS are not the only possibility. Unsophisticated, non-technical approaches based on the observation of environmental processes like rising river levels, are used worldwide. This alternative is called community flood EWS. These systems, devised by local people and communities, were amongst the earliest EWS and are still being used by communities where there is no formalized EWS. However, these are not less important than centralized EWS.

[27] Molinari D. and Handmer J., 2011

The review of some study cases[28] [29] [30] of linear EWS for flooding highlight the following shortcomings:

- The focus tends to remain on the hazard, with less emphasis on the vulnerabilities, risks and response capacities.
- The flood risk information provided with early warning is not always accurate.
- The various hazards are typically dealt by separate independent technical institutions, with few mutual benefits being sought. Hence, the coordination among these institutions is minimal.
- The dominance of the expert can lead to difficulties in user appreciation of such things as the meaning of a warning, warning uncertainty, the nature of false alarms and the necessary responses to different types of warnings.
- The role of research and knowledge from outside the core area of expertise is often not acknowledged.
- There is little engagement or empowerment of those at risk in the design and operation of the warning system, and therefore, a tendency by users to lack any sense of ownership in the system and therefore, to mistrust the experts and authorities.
- There are few systematic mechanisms to improve the system through the incorporation of the knowledge, experience and feedback from users and those at risk.
- Weak public engagement and recognition tends to lead to weak political and budgetary support for the warning system.

[28] Basher R., 2006

[29] Shah M.A.R., Douven W.J.A.M., Werner M. and Leentvaar J., 2012

[30] Molinari D. and Handmer J., 2011

Analyzing these shortcomings shows that it is clear that the main problems lie in the lack of participation by the stakeholders. This MSc Thesis, thus, is based on the premise that the combination of centralized and community flood EWS establish the optimal flood warning system. With the purpose of increasing the likelihood of successful design and implementation of the EWS for flooding, all relevant stakeholders should be involved in the development of the system to ensure that the issues of greatest concern are identified and addressed, including interviewing persons that have previously been affected by natural disasters. Local knowledge about responses and their effectiveness may offer a great contribution in the development of the optimal EWS[31]. In this context, it is important to consider that the principle of non-discrimination is a fundamental tool to guarantee the inclusion of disadvantaged groups in participation processes[32].

4.1.1. Analysis of monitoring and warning service

In terms of disaster management, it is crucial to understand flood hazards not only during the event and when the flood emergencies are activated but also before the event takes place so that mitigation, preparation and damage reduction activities can be carried out. In order to understand flood hazards, knowledge of the various types of flooding, their probability, location and frequency of occurrence, how to model and map them, what the required input data are, amongst others, is required[33].

Floods are usually the result of a combination of factors including meteorological and hydrological extremes, land use or from the breach of a dam, etc. The classification of floods

[31] Klingberg P., 2011

[32] Gruenberg C., 2007

[33] Jha A., Bloch R. and Lamond J., 2011

is based on a combination of sources, causes and impacts. As a result, the types of flooding are: urban flood, pluvial and overland flood, coastal, groundwater, flash flood and semi-permanent flooding.

The estimation of flood probability is the combination of statistics, climatology, meteorology, hydrology, hydraulic engineering and geography of the specific basin. In the case there is no data available or the data are of poor quality, data from other neighboring basins are interpolated to the basin of interest. A rainfall-runoff model is used to estimate the river flow. A hydraulic model is then used to obtain the depth and extent of the resulting flood. Finally, geographic data such as topographic, population data are required in order to compute the flood hazard.

The required input flood data used for modeling, evaluation and forecast are quantitative and qualitative[34]. Quantitative flood data include hydrometeorological data, descriptions of the type of areas affected, depth and velocity. These data can be gathered from environmental agencies, government environment ministries and also from the local municipality. In terms of measurement devices, hydrological data can be obtained from monitoring stations, gauging stations, satellite imageries, etc.

When modeling and mapping flood hazards, it must be noted that the models required for hazard assessment and flood forecasting are approximations of reality, which means that models suffer from a certain level of approximation or uncertainty. As a result, the reliability of flood forecasting models relies on the quantification of uncertainty. Several sources of uncertainty can be distinguished: model, parameter, input or natural and operational uncertainty.

[34] OEA, 2010

Models in operational forecasting systems can be categorized into several types depending upon their input data, level of complexity and resolution. Three types of models have been identified in Table 3[35].

Physically based models	Data driven models	Conceptual models

• Hydrodynamic models
  • One dimensional models (1D)
  • Two dimensional models (2D)
• Flood Inundation models
  • Quasi-two dimensional models (quasi-2D)
  • Three dimensional models (3D)
	• Regression models / Correlations
	• Transfer function type models
		• Hydrological rainfall-runoff models (incl. snow models)
		• Hydrological routing models
		• Reservoir models

Table 3: Models in operational forecasting systems

Some examples of flood forecasting and Early Warning Systems are DELFT-FEWS, ALERT, Central America Flash Flood Guidance, the Mekong River Commission flood forecasting system, SFM, ARA-Sull, amongst others. Since this project will use Delft-FEWS for the development and implementation of the flood EWS in the region of Beni, this system is rigorously described in this Thesis.

Until now, forecasting systems were commonly built around the existing model. This traditional approach is called model centric. However, one important disadvantage is that it focuses on running the model without a clear understanding of how the lead time provided fits with the information required

[35] Werner M., undated

by each stakeholder. After some research[36] has been carried out in order to examine the effectiveness of EWS, the need for a new framework for establishing forecasts requirements has been identified. This new approach is called *data centric* and is based on:

- Identification of stakeholder need for information: what, where and lead time
- Identification of how this data can be provided

This new approach that will be used in this MSc Thesis focuses on the identification of the information needed at a lead time based on the specific use of data. Data and models are then analyzed to understand how this lead time can be achieved. More specifically, it identifies the spatial distribution of end-users and the time scales and lead times at which forecasts are required. These needs are then translated into requirements for monitoring, modeling and meteorological forecasting. Moreover, the identification where requirements cannot be met by existing capabilities can be achieved by doing a gap analysis and then, based on this analysis, some recommendations for improvements can be presented. Another advantage is that the resulting flow forecasting system is built on available knowledge and capabilities, increasing its acceptance by the stakeholders involved, including end-users.

Depending on the stakeholder and the type of information required, the lead time at which information is best provided will vary, as well as the balance between accuracy and timeliness. Figure 10 displays the relation between forecast accuracy and value. As the forecast lead time increases, the accuracy of the forecast values will reduce. This implies that although the potential benefit of forecasts to all stakeholders will increase as more time is available to take action, a balance between the lead time used to take action

[36] Werner M., undated

and the uncertainty of the forecast, which may result in a wrong decision being made, must be found by each stakeholder.

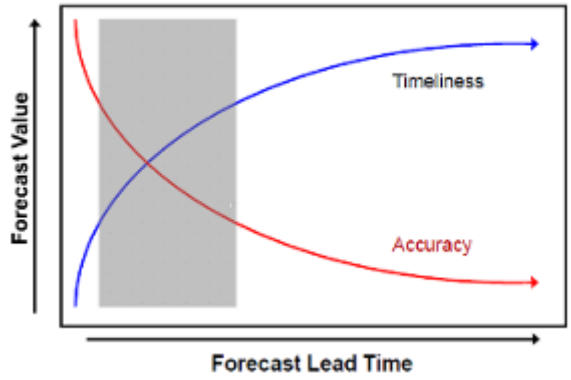

Figure 10: Relation between forecast accuracy and value[37]

The identification and analysis of the use of the information by each stakeholder is necessary for the proper development of the flood EWS, as the ideal lead time will differ considerably from one stakeholder to another. In order to simplify the analysis of lead time requirements, these are classified into three types of forecasts[38]:

- Short range
- Medium and extended range
- Seasonal

After identifying and analyzing the desired lead times of stakeholders as well as the locations of interests and the information required, the location of all stakeholders is required in order to develop maps of the basin and plot their locations across the basin. For each of the locations at which a forecast is to be provided, an estimate must be made of the lag times in the basin upstream of that point. The purpose is meeting lead times with lag times. As a conclusion, depending on the location of each stakeholder within the basin, the data and information used to build the forecast will be different.

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[37] Werner M., undated

[38] Werner M., Winsemius H.C. and Robinson B., 2011

4.1.2. Analysis of warning dissemination and communication

This subchapter focuses on warning dissemination and communication, which is one of the elements of the warning chain that will be analyzed in this MSc Thesis. Although some research has been carried out in order to analyze the effectiveness of EWS, most of the studies do not focus their research in this study field. Even today, most investments are made into flood detection and forecasting. Comparatively little attention has been focused upon the process of disseminating flood warnings.

This thesis assess the efficiency and effectiveness of warning and communication technologies in Bolivia that are currently used within the early warning information dissemination network. Based on this assessment, the current warning information and its improvement, if necessary, will be carried out considering the fact that warning service need to be accurate, timely and reliable, so that the benefits of flood detection and forecasting are captured as fully as possible. The specification of available, feasible and sustainable communication technologies that can be included or removed from the current dissemination network is carried out. The justification of each choice will be based on the fact that the successful design and implementation of the new EWS in Beni has a substantial dependency on the way in which the warnings are communicated to target individuals, communities and organizations and thereby, on the types of communication technologies used.

A large number of factors have been documented, which influence the warning dissemination in EWS. Some factors have a considerable influence not only on warning dissemination but also on communication. This is the reason why warning dissemination and communication is considered as one element

of the warning chain: Warning. According to Mileti, the warning factors that govern people's response to the provision of early warning are warning source, warning frequency, accuracy of warning, warning message consistency, warning clarity, sufficiency of information, the certainty of the event, information on flood risk at the recipients location and guidance on response.

i. Warning source. The source of warning may be an individual or an agency. It is crucial that both seem credible and reliable to the people receiving the warnings. Due to the fact that people have different perceptions of credibility, warnings are considered most credible if they come from a mixed set of persons.
ii. Warning frequency. In order to reduce anxiety created by the lack of information on the actual situation and to reduce the possible effects of misinformation and misperceptions or to reduce rumors and increase the confidence of recipients, frequent messages need to be used when warnings are disseminated. The frequency of warning depends on the needs of the public at risk. Although people want updates of information even when little changes occur, the effectiveness of warning decreases with too many warnings.
iii. Message accuracy. Accuracy, timely and complete data are crucial characteristics of a warning message. Literature[39] highlights the dramatic effects on success when people have the perception that the 'whole truth' is not being exposed.
iv. Warning message consistency. Consistency of the warning information with the disaster situation is essential. Updating of the situation with explanations for changed conditions is a proper way to maintain consistency.
v. Warning clarity. The use of clear words reduces people's misunderstanding. Also the message needs to be worded in simple language.

[39] Mileti D., 1995

vi. Sufficiency of information. Hazards should be described with enough detail in order to allow all receivers to understand the character of the disaster event. Information about physical characteristics of the hazard induces an increase of risk perception and thus the enhancement of protective actions by receivers.

vii. Certainty of the message. As certainty determines the level of belief in a warning, a message must convey certainty, even if there is a low probability of hazard.

viii. Risk location information. It is evident that warning information should be addressed to flood-prone communities; however, the inclusion of other non-target communities is also recommended.

ix. Guidance on response. The warning message must give information about what people have to do and how much time they have in which to act.

In conclusion, effective warning messages must be consistent, accurate, certain, clearly understandable with location specific risk, as well as including guidance on response activities that can be taken. It is also important that the warning is repeated frequently and labeled as coming from a panel of officials, scientists and credible experts. The impact location, protective actions to take, the lead time and the character of risk must be effectively clarified in the warning information.

Literature[40] highlights the fact that EWS are communication systems that link a variety of organizational stakeholders to each other and then to the citizens involved. Communication systems involve communication devices and systems that, in conjunction with stakeholders establish a large and complex flood early warning information dissemination network from national to local level. As a result, the effectiveness of flood EWS is based on the social performance of technology and

[40] Tapsell S., Burton R., Oakes S. and Parker D., 2005

target groups. This also depends on a range of factors including flood warning technologies, recipient characteristics and barriers to communication. Time is also considered as a relevant factor as over time, individuals, communities and institutions are capable of increasing their knowledge of learning about and utilizing communication technologies.

a) Flood warning technologies

Today a large range of flood warning technologies are available. These technologies vary from in use well-tried and comparatively new technologies to emerging technologies known as near future technologies. In Table 4 the available flood warning technologies are listed. Well-tried technologies include radio and TV, door knocking, sirens and the conventional telephone, amongst others. Relatively new and recent technologies are included in the second column. Mobile telephones, electronic mails and internet are part of comparatively new technologies. Finally, potential technologies are still under development consist of SMS texts, real time flood data on the web, etc.

Well-tried and in use	Comparatively new and in use	Near future, potential and/or advanced
• Standard analogue telephone • Door knocking • Mobile loudhailer • Written communication • Flood wardens • Flood sirens • Radio telephone • Radio • Facsimile • Automatic water level alerts linked to telephone	• Press-button digital telephone • Mobile telephone and voice mail • Pagers • Automatic Voice Messaging (AVM) using telephone • Teletext • Dial-and-listen services (Floodline) • Television/radio broadcast • Signage • Intranet and internet websites with real-time warnings • Electronic mail	• Mobile telephone SMS text messaging and SMS Cell Broadcast • Digital TV and Digital Audio Broadcast • Dedicated public address systems • Wireless Application Protocol telephones • Centrally activated local radio alerts • Centrally activated in-home alert systems • Integrated dial-and-listen and AVM services • Real time flood data on web • Third or fourth generation mobile telephones • Others*

* Crawlers on standard TV, power Line, the Grid, mesh network, Bluetooth, ZigBee, radio data system, light as a medium, ultra wide band, Software Defined Radio, Ad hoc networks and other wireless protocols.

Table 4: Flood warning technologies[41]

[41] Tapsell S., Burton R., Oakes S. and Parker D., 2005

Although it could be easily assumed that advanced warning technologies are more effective and so should take preference over other alternatives including traditional and new communication methods, literature on international study cases[42] [43] documents that there is still a predominance of traditional warning systems such as door knocking, telephone, radio, TV and sirens.

The review of the flood warning literature[44] [45] highlights the considerable influence that using multiple, at least two, independent, communication technologies, as well as, the ability to confirm information received from these sources through other warning technologies have on EWS effectiveness. As a result, flood warning communication methods should consider the adoption of a heterogeneous approach to flood warning dissemination using a combination of communication technologies based on the specific characteristics of each individual and community.

Flood warning methods also fall into two other categories according to their target recipients. Mass Notification Methods and Addressable Notification Methods are two alternatives:

Mass Notification Methods are systems that are not individually addressable and commonly provide the same alert or message to the recipients within a geographic area, regardless of level of individual risk. These methods include two variants: Outdoor Systems, for instance, sirens and loudhailers, amongst others; and Mass Broadcasting Systems like conventional radio and television.

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[42] Gruntfest E., Carsell K. and Plush T., 2002

[43] Blancher P., 2001

[44] Mileti D., 1995

[45] Shah M.A.R., Douven W.J.A.M., Werner M. and Leentvaar J., 2012

Addressable Notification Methods can tailor and target alerts and messages to only those at risk or to specific groups. These methods include three variants: Broadcasting Systems such as amateur radio, Telecommunication Systems including telephone, internet, Cellular and Short Message Service, etc. and Personal Systems such as door-to-door and residential route-warning (using mobile public address systems)[46]. It must be taken into account when choosing the communication technologies that all of them have strengths and weaknesses. Hence, a proper analysis is crucial before the choice of the warning technologies for the new flood EWS in Beni is made.

b) Recipient characteristics

This study comes from the premise that the communities and organizations involved within the flood EWS in Beni are heterogeneous in composition. It is assumed that these communities and organizations comprise people of all ages, from different socio-economic and income groups, different gender groups and different ethnic groups. Also people that have special needs, for instance, the blind, deaf, physically disabled, etc. are considered.

Risk perception, flood experiences and experience with the technology, awareness of the existence of the technology, the manner in which the technology is introduced and promoted, the degree of perceived benefits and disadvantages to users, the reputation of the agency, the reputation of the technology (effectiveness) and annual costs are factors that also have a tremendous impact on the receptiveness of the stakeholders and inhabitants, to communication technologies. Therefore, the new flood EWS needs to take into account the large number of factors that influences the effectiveness of warning dissemination and communication.

[46] Anderson P., 2006

c) Barriers to communication

A variety of social and economic characteristics as well as local physical and institutional contexts may also affect the access and adoption of technologies. Some barriers may be age, language, educational attainment level, composition and density of the resident population, local, regional and national structures of governance, community leaders, etc. According to Tapsell *et al*. (2005), it is necessary to distinguish between individuals and communities of high and low perceived risk.

Based on the factors that influence the warning dissemination and communication, the specific analytical variables that have to be considered to assess the existing flood Early Warning System are listed below. Moreover, a more detailed classification of these variables is available in Annex 1.

- Gender
- Age
- Disability
- Ethnic minority
- Language
- Educational attainment level
- Social ties
- Socio-economic group
- Work and Resources
- Previous experiences
- Lead time
- Warning levels
- Experience with technology
- Knowledge about technology
- Manner in which technology is introduced
- Reputation of technology
- Perceived benefits and disadvantages
- Warning source
- Reputation of agency
- Structures of governance
- Structures of other agencies
- Annual costs
- Warning frequency
- Risk location information
- Warning clarity
- Sufficient information
- Message accuracy
- Certain of message
- Warning message consistency
- Confirm the threat
- Guidance
- Personal damage

4.1.3. Analysis of flood responses

People perceptions, including thoughts, feelings and intentions, as well as social characteristics have a considerable influence on flood preparedness, on warning communication and on the general effectiveness of a flood warning system. According to UNISDR, there is a correlation between people's perceptions and risk knowledge. Thus, the successful implementation of the EWS-Beni, particularly the response, is subject to people's risk knowledge. Levels of risk awareness depend largely on the quantity and quality of available information and on the difference in people's perceptions of risk. It must be mentioned that people are more vulnerable when they are not aware of the hazards that pose a threat to their lives and property.

Although linear EWS for flooding focus on the hazard itself, which implies that both monitoring and forecasting are the elements of the warning chain that are more highlighted, the effectiveness of the warning system is subject to the proper operation of all elements that compose the warning chain. Hence, some research on how the communities at risk respond to flood warnings is essential to assess the effectiveness of the existing warning system. Thus, in order to assess the existing Flood Early Warning System, it is considered desirable that both risk knowledge and preparedness intentions are analyzed.

People characteristics including perception of risk and social characteristics have an influence on the shortcomings of people's response to warnings. The propensity of an individual to become involved in safety initiatives is closely linked to their perceptions of their own susceptibility (for example how often they feel that an incident will occur), vulnerability (how likely they feel that they will be directly affected by an incident), and recoverability (how easily people feel that they would recover from an incident). The concept of vulnerability includes some variations due to scientific

disagreements in the research field[47]. This Thesis will consider the conceptual vulnerability model from Marchand (2009)[48] as the basis for this study. This model integrates exposure, sensitivity and resilience within the concept of vulnerability. Literature[49] also highlights six general categories of people characteristics that have a bearing on the take up of warning methods and the actions taken upon receipt of a flood warning:

- environmental cues
- psychological characteristics
- pre-warning perceptions
- social setting
- social ties, and
- socio-demographic characteristics

Environmental cues include the visibility of the hazard in the locality. Location of the risk or geographical proximity of those at risk to the impending threat as identified and plays an important role in people's response.

Cognitive abilities and personality are examples of psychological characteristics that can influence reception of a warning.

Pre-warning perceptions are based on similar experiences from past events. These three characteristics are important for trusting and confirming the threat transmitted by the early warning information.

Social setting factors characterize the context in which the emergency information is received. Family unity is fundamental in achieving better results for people's response.

Social ties like relationships with neighbors need to be assessed. Socio-demographic characteristics like resources, gender and socioeconomic class can also have an impact on the effectiveness of response to warnings. Hence, social setting,

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[47] Odgers P. and Rhodes A., 2002

[48] Marchand M., 2009

[49] Mileti D., 1995

social ties and socio-demographic characteristics will impact on the response taken to warning information.

Citizens reactions to warnings is a social psychological process that is divided into various human behavioral steps based on personal definitions about the risk they face and their ideas about what to do before take a protective action. The model[50] used for the analysis of this process is in the form of an event tree that contains the possible steps that a person would follow when the probability of a natural disaster is high and the warning is activated (see Figure 11). In order to shape the possible human behavioral steps in response to the warning, six steps have been identified as taking place after a warning: Noticing, Understanding, Considering a target, Trusting, Confirming and Acting. Three kinds of warnings are included in the event tree model, an official warning, an unofficial warning and no warning.

The first behavioral step is noticing because it cannot be assumed that everyone will notice every emergency warning. Even when it is physically possible for people to hear a warning, some factors may cause a failure to hear it, for instance, people may fail to listen because of perception or selective perception. Understanding a warning, that is personally attaching meaning to the message, is the second step. Understanding varies among people, thereby; in some cases the meaning intended by those who issued the warning is not confirmed. According to *Mileti* (1995)[51], emergency warning information must be able to provide the people with accurate and common understandings of risk and hazards. The different understandings that might emerge if an emergency occurs can be avoided with proper planning. Understanding is followed by considering oneself the target for warning. This behavioral step is based on the fact that, people will only act if they

[50] Molinari D. and Handmer J., 2011

[51] Mileti D., 1995

think that they are the targets of emergency information. Only then might they carry out the stipulated response. In order to achieve this goal, the significance of personalizing the warning should be highlighted.

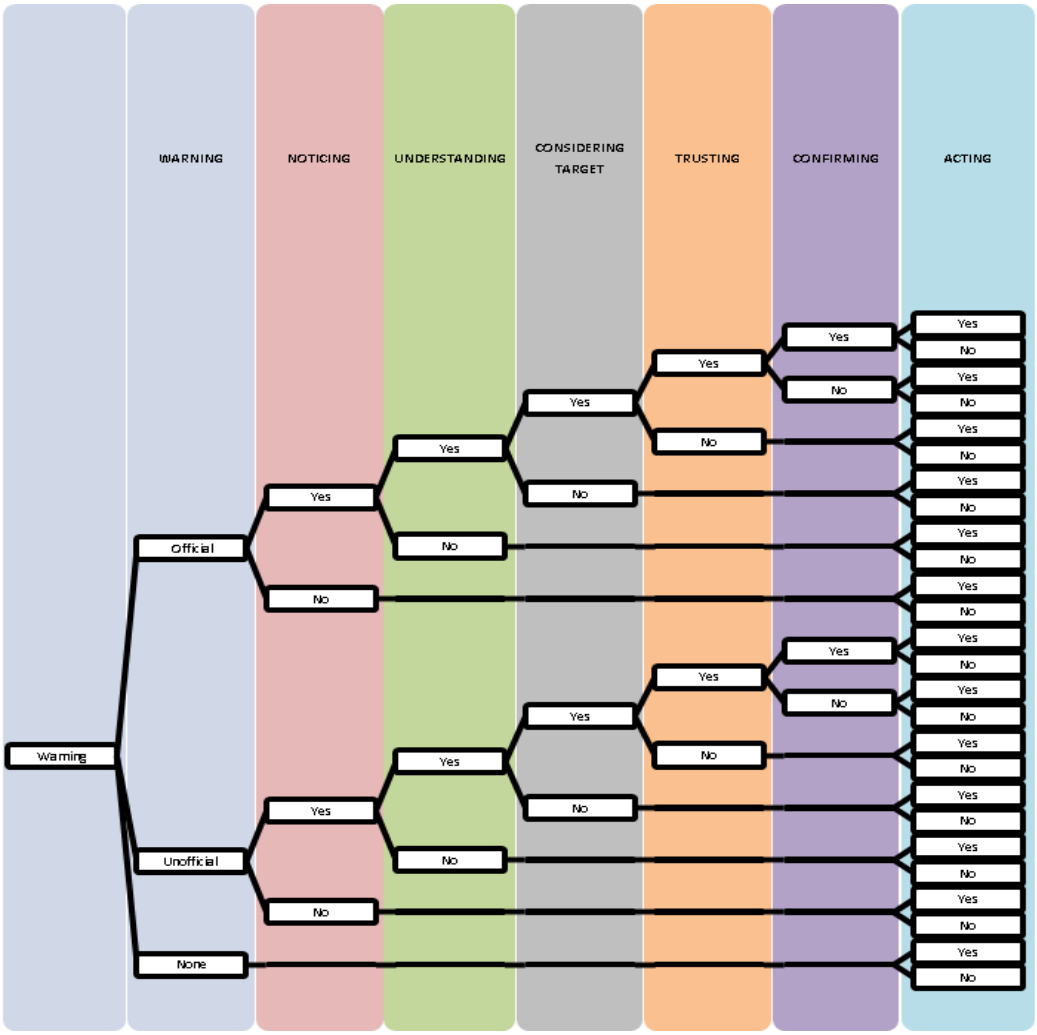

Figure 11: Model to analyse people responses to warning[52]

Trust in the warning information depends basically on believing that the warning is real and that the contents of the message are accurate. Once these four steps are achieved satisfactorily, people become conscious that an imminent disaster will occur; however before acting, most people will actively seek out additional information in another warning message or from another warning source or person in order to

[52] Molinari D. and Handmer J., 2011

verify the warning already heard. Acting, which is the last behavioral step, depends on the personal perceptions formed after hearing the emergency information, forming an understanding of the message, defining a level of belief and finally, determining a level of risk.

Analyzing some study cases[53] about how people respond to the flood warning, some issues have been detected, which are likely to occur every time a warning is provided:

- Not all people notice the warning
- Although people have noticed the warning, not all of them are able to understand the meaning of the warning
- Although people have noticed the warning, they do not consider themselves at risk, thereby, thinking that the warning does not apply to them
- Not everyone trusts the warning
- Before taking action, some people seek confirmation of the warning
- Not everyone knows how or is able to react

Finally, the effectiveness of a flood EWS depends largely on citizen's flood preparedness. For the analysis of the current EWS in Beni, citizen's flood risk perceptions, their knowledge of risk and their previous flood hazard experiences are assessed. The influence that experience of disaster has on people's risk perceptions varies considerably. On the one hand, some research studies[54] have shown that experience increases people's risk perceptions. On the other hand, some authors[55] highlight the opposite conclusion. Finally, other studies[56] have documented that the effects of previous hazard

[53] Shah M.A.R., Douven W.J.A.M., Werner M. and Leentvaar J., 2012

[54] Siegrist M. and Gutscher H., 2006

[55] Halpern Felsher B., Millstein S., Ellen J., Adler N. Tschann J. and Biehl M., 2001

[56] Lindell M. and Perry R., 2004

experiences also depends on how people interpret their experiences (see Figure 12). Despite these diverse and difference of opinions, it can be assumed that positive and negative emotions related to previous flood hazard experiences would influence risk perceptions and, thus, preparedness intentions. Positive feelings like feelings of relief, solidarity and unity, among others, are important because they add to people's social and psychological resources, which are indispensable for coping with the negative consequences of flooding. However, the results from the research study about flood preparedness carried out in the Netherlands in 2009[57] show that citizens frequently evoke more negative emotions when recalling their previous flood hazard experiences. Negative feelings generally reflect fear, worries, helplessness, sadness, etc.

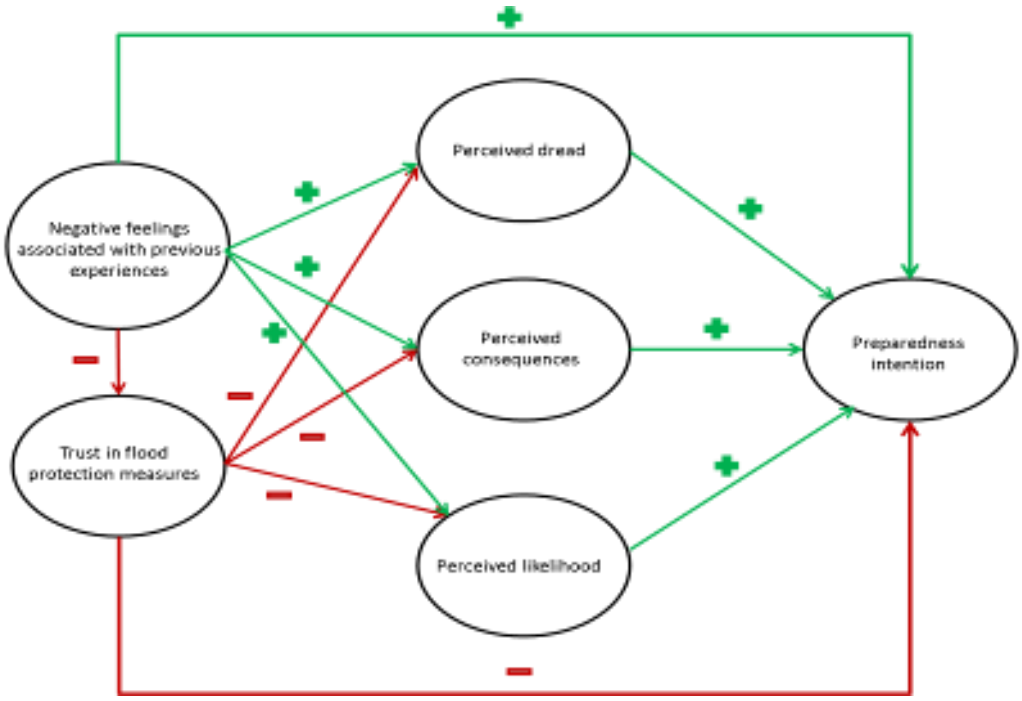

Figure 12: Preparedness behaviour

The specific analytical variables that have to be considered to assess the current flood Early Warning System in the Beni

[57] Terpstra T., 2009

are listed below. Moreover, a more detailed classification of these variables is available in Annex 1.

- Gender
- Age
- Disability
- Ethnic minority
- Language
- Educational attainment level
- Social ties
- Socio-economic group
- Work and Resources
- Previous experiences
- Environmental cues
- Warning levels
- Reputation of technology
- Psychological characteristics
- Behavioral consequences
- Warning source
- Reputation of agency
- Structures of governance
- Structures of other agencies
- Warning clarity
- Sufficient information
- Message accuracy
- Certain of message
- Warning message consistency
- Confirm the threat
- Guidance
- Personal damage
- Response
- Estimated loses
- Preparedness

4.2. Adressing the research questions – activities carried out

This subchapter aims to list the specific activities that are carried out in order to answer the research questions.

Research question 1: *Who are the stakeholders and what are their specific roles within the field of flood Early Warning Systems in Beni?*
Activities carried out:

- Literature review about stakeholder analysis
- Identification of stakeholders involved in the existing EWS in Beni and who will be involved in the new system. These are disaggregated in main stakeholders and other relevant stakeholders
- Analysis of the specific roles of each stakeholder involved in the existing EWS in Beni and who will be involved in the new system

The identification of the stakeholders and their specific roles within the existing flood EWS has been carried out using literature reviews such as written documents, annual reports, websites, etc. and interviews with stakeholders, as well as, interviews with other stakeholders about each other's positions. Moreover, group discussions like workshops have been a useful method for mapping the stakeholder network. Finally, interviews with experts on the problem were also proven to be appropriate.

Research question 2: *What are the interests and needs of each stakeholder involved?*
Activities carried out:

- Literature review about the perceptions and needs of people
- Literature review about interviews and group discussions
- Analysis of people's perceptions and experiences

- Identification of the interests and needs of the stakeholders disaggregated in impact reduction and the warning system per se

These activities have been carried out mainly using group discussions, including workshops; however interviews were also considered an assessment tool if required. Literature reviews and searches of the internet are included in order to identify the various methodologies to assess perceptions, interest and needs.

Research question 3: *What are the strengths and weaknesses of the existing Early Warning System?*

Activities carried out:

- Literature review about the field of flood early warning systems at local, national and international level
- Review of the official documents about the existing EWS in the region of Beni
- Assessment of the current Early Warning System including the warning information dissemination network, warning levels, communication technologies, stakeholders involved, risk knowledge, amongst others.
- Assess the actually performance of the system during flooding season in 2013

The identification of the strengths and weaknesses of the current flood EWS is based on literature review and case studies worldwide and in Bolivia. Interviewing various stakeholders involved within the EWS, as well as, holding group discussions led to a greater amount of information on the system being obtained.

Research question 4: *What are the recommendations for the design and implementation of the new flood Early Warning System considering the needs of the stakeholders?*

Activities carried out:

- Recommendations for the stakeholders involved in the new flood EWS

- Definition of the early warning information dissemination network
- Establishment of the required information and tools for each activity of the EWS and for each stakeholder including the use of hydrological information, warning information, communication technology, trainings (and content), among others.

Discussion meetings with key Deltares staff have been crucial for indicating possible improvements to the new flood EWS. Recommendations given by the interests and needs assessment are limited to either feasible and sustainable technologies or to the issue of improving participation and coordination among different institutions and organizations.

4.3. Assessment methodology

A number of methods have been employed for data gathering for this MSc Thesis. The general approach is qualitative and involving the methods listed below:

- Literature reviews
- Searches of the internet
- Direct contact with individuals and organizations in Bolivia through interviews and group discussions
- Discussion meetings with key Deltares staff

It has been considered appropriate to base the analysis of the existing EWS and needs and interest on various interviews and group discussions with citizens and experts from organizations and institutions involved in the EWS for flooding in the region of Beni. These data will be used as primary sources; however, since criticism of sources is always suggested when using interviews in research[58], the quality and consistency of gathered data have been assessed using studies already done. Furthermore, the knowledge and expertise of some experts from

[58] Pratt B. and Loizos P., 1992

other organizations and institutions that work in similar projects in other regions combined with experiences of citizens who live in regions where a EWS for flooding has already been developed and successfully implemented have been a supplementary useful assessment tool.

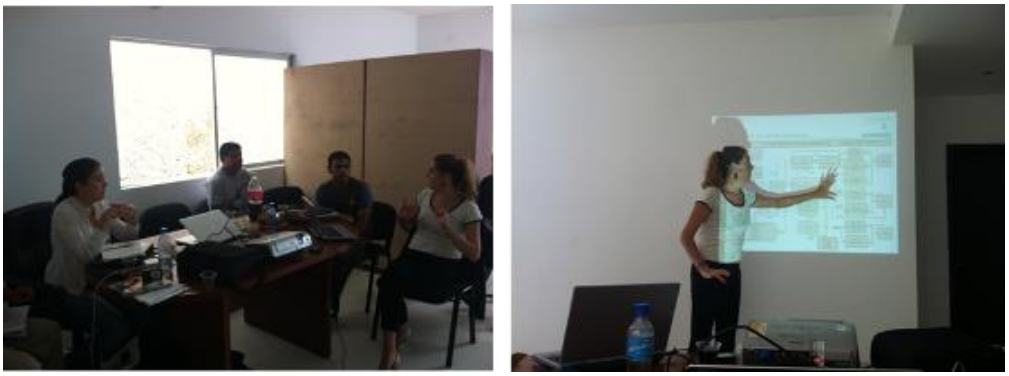

Figure 13: Discussion meeting in Trinidad with VRHR and UGRs

The stakeholder analysis and the assessment of the current EWS in the department of Beni are based on the identification of the strengths and weaknesses of the system considering the literature review, but more specially, interviews and group discussions. By interviewing various stakeholders involved within the EWS, a greater amount of information on the system have been obtained.

Although it could be easily assumed that interview programs are just questionnaires, developing an interview program includes instructions for the introduction of the conversation, for making notes, for finishing the conversation, for the formulation of questions, for assessing the answers in order to identify the most relevant, amongst others. The construction of an interview program consists of ten steps[59]. Identifying the purpose of the interview is the first step followed by the identification of variables. Since interviews are carried out to collect information, is essential to identify the information that is required for the study and thus, it must be considered when designing the

[59] Emans B., 1990

questions to be used in the interview. In order to collect information, three different types of questions can be used: open questions with field coding, open questions without field coding and closed question. The difference between open and close questions lies in the formulation of the answer. In closed questions, the recipient receives a list of possible responses. In open questions the possible response list disappears and the interviewee responds with whatever seems desirable. The methodology for making notes about the respondent answers is established at this step of designing the interview program. Some instructions for asking questions must be considered, for instance, are the questions categorized into structured or unstructured? Once the questions have been prepared, the order of the questions is then established. The penultimate step before the computer-aided construction of the program and the definitive schema is to plan the lay-out, the introduction and the conclusion of the interview.

In group discussions the interviewer guides a conversation among a small group of people chosen because of their similar interests[60]. Unlike interviews, group discussions are always semi-structured, since the interviewer's skills are used to introduce a list of topics, to encourage participants to take part in the discussion and to identify the concerns, perceptions, needs, interests, etc. of the group members. In order to achieve a proper view of the situation and reality, the group members should have similar backgrounds. It is also important that the participants feel at ease with one another and feel free to state their point of view openly. Such discussions, as individual interviews, are valuable when planning more formal research.

Furthermore, the interview, a group discussion or more specifically the form of asking questions needs to be tailored

[60] Nichols P., 1991

to the cultural perceptions and other factors pertinent to the group in question[61]. In many societies a structural inequality exists that interferes with freedom of opinion and participation in the research process. Frequently there can be the culture of silence[62], which is resistance to outside intervention which can manifest itself in a lack of cooperation with the researcher. This lack of cooperation may be based on bitter past experiences and it may be necessary to make brief background research attempts in order to identify the origins of the problem. Moreover, in some cultures, access to certain groups is restricted, for instance, access to women or the disabled. Usually these groups are kept hidden from outsiders in their own homes. However, proper research implies the involvement of these groups; thereby, it is important to identify these people and where they are. These people also need to be given the opportunity to express themselves; which implies that the development of a style that permits this encounter is needed. For such people who usually do not have the opportunity to voice their concerns, research can be a useful tool to encourage them to articulate their needs, interests, perceptions and experiences.

Information about the efficiency of the current EWS, as well as, perceptions, risk knowledge and experiences from the population have been obtained by interviewing some citizens that live in target flooding areas in the department of Beni, specifically, Trinidad, Loreto and San Ignacio de Moxos. As a result, data on the flood response by citizens were collected through interviews among 21 households. In order to have an extended view of people's perceptions and experiences, a variety of communities, villages and cities have been considered for the interviews. Some cities and villages are protected from floods by using some structural measures like protector rings constructed around the city or village. This

[61] Deltares and Rijkswaterstaat, 2011

[62] Pratt B. and Loizos P., 1992

the case with Santa Ana de Yacuma, San Ignacio de Moxos and Trinidad. Moreover, some communities located near the river were also considered for the interviews, as these areas are not protected from events. The interview consisted of 132 questions based on the parameters described before. The questions have been categorized into different groups:

- People characteristics
- Risk knowledge, Perceptions and Experiences
- Warning – Lead Time
- Warning – Warning Dissemination Methods
- Warning – Agents
- Warning – Warning message
- Warning – Message contents
- Response
- Emergency measures
- Preparedness

The interview structure is available in Annex 2. A large proportion of the questions are open questions; however, people characteristics, which hold crucial information for the assessment, have been asked as closed questions. In order to achieve a real analysis of the effectiveness of the current EWS, not only living areas have been considered while doing the interviews but also inhabitants with very different characteristics were interviewed.

Moreover, two examples of interviews with national institutions are shown in Annex 3. Finally, in Annex 4 there is a list of some interviews recorded during the time in Bolivia. The amount of interviews carried out in Bolivia reach almost 100.

4.4. Limitations of the study

The main constraint of this MSc Thesis is the lack of research studies about flood Early Warning Systems based on a multi-level stakeholder involved approach. The small number of existing studies is mainly from urban areas in industrialized countries, for instance, North America, United Kingdom and Australia; thus the lack of information is even more striking in the context of rural areas in developing countries. Furthermore, another limitation is the fact that reaching a multi-level stakeholder consensus on the complex issue of the EWS for flooding with multiple interests is a lengthy and difficult process, which is beyond the scope of a MSc research.

A further important gap in the literature concerns the specific area of warning dissemination and communication of flood warnings. That is mostly because EWS focus on the hazard itself which means that monitoring and forecasting are considered the most relevant activities within the flood EWS.

5. Stakeholders, interests and needs

Considering the premise that figuring out what the problem is and what solutions might work are actually part of the problem, taking stakeholders into account is a crucial aspect of problem solving. This chapter shows the results obtained from interviews and group discussions, as well as, what the literature says regarding the level of involvement of the stakeholders within the current and new EWS Beni. The identification of the main and other relevant stakeholders that take an active role in the existing EWS and a brief description of them is part of the stakeholder analysis. Moreover, the particular interests and needs of each group are addressed as the last point of this chapter. Therefore, the stakeholder analysis presented in this chapter aims to respond both research questions:

- *Who are the stakeholders and what are their specific roles within the field of flood Early Warning Systems in Beni?*

- *What are the interests and needs of each stakeholder involved?*

5.1. Stakeholder involvement

The concept "stakeholder" has assumed in the last decade a prominent place in public and non-profit management theory. Although the definition of this concept differs with respect to how inclusive the authors are, a stakeholder can be defined as an actor or group of actors that has an interest or stake in a decision, but relatively little means to influence the decision making process or system[63]. Attention to stakeholders is important for three main reasons, it is important throughout the strategic management process, it is needed to assess and enhance political feasibility, and finally, attention to stakeholders is important to satisfy those involved and affected. However, it must be noted that not all possible stakeholders should be satisfied, or involved within the project, but only the key stakeholders[64]. Due to the fact that stakeholder involvement is a key element to achieving an effective and sustainable system, stakeholder analysis can make an important contribution to creating value through their significant impact on the achievement successful results.

EWS seen as a warning chain focusses mostly on the monitoring and warning service element; however, some research studies[65][66][67] have documented that the effectiveness of a EWS based on achieving the desired reduction in losses and impacts in the short and long term is also influenced by the human factor. As a result, in some cases technically high-quality models have been used for monitoring and forecasting but the expected results by implementing the presumed optimal EWS have not been

[63] Enserink B., 2008

[64] Bryson J., 2004

[65] Klingberg P., 2011

[66] Shah M.A.R., Douven W.J.A.M., Werner M. and Leentvaar J., 2012

[67] Barthelt C. and Loster T., 2012

achieved. The main cause was the failure in the communication and preparedness elements. As a result, the involvement of stakeholders improves insight into the field of forces, for instance, perceptions, interests, needs, capabilities, etc. and contributes to a better approach to a solution. It also reduces the chance that important risks are forgotten and finally, it increases the chance that various stakeholders are willing to lend their cooperation to solving the problem.

Figure 14: Stakeholders identification and involvement

5.2. Mapping of stakeholders

The stakeholder and network analysis carried out in this MSc Thesis is based on the six steps identified by Enserink (2008)[68] considered as the guideline for achieving a proper analysis of the current EWS in the Mamoré river basin. The first step consists of the formulation of the problem. The problem analysis has already been outlined in chapter 3. The rest of the steps will be explored over following chapters. This chapter reports on the identification of the stakeholders that are involved in the existing EWS in Beni and will be involved in the new system. These are disaggregated into main stakeholders and other relevant stakeholders.

[68] Enserink B., 2008

After mapping the stakeholders involved within the issue of flood EWS in Bolivia and more specifically those who will play an important role in the Mamoré river basin (see Figure 15), an inventory of them, disaggregated into primary and secondary stakeholders, is presented. The inventory first includes a brief description, followed by the elements of the warning chain in which they have an important role and finally, their capabilities regarding with the Flood EWS. Moreover, the municipalities which benefit from the project "*Diseño e desarrollo del SAT-Beni*" have been identified. These have been also disaggregated into direct and indirect beneficiaries.

The involvement of stakeholders within the new EWS is based on the knowledge and experiences of the existing EWS in Beni and in other departments. The appropriate changes are the posterior step after a first identification and analysis of the strengths and weaknesses of the current EWS. In general terms, the institutions and organizations that are considered to have relevant involvement in the improvement of the design and development of the new EWS are:

- Organisations that finance the development and operation of the system
- Groups interested in being involved and taking action
- Potential groups affected by flooding, including those who have already had some experience with previous natural disasters

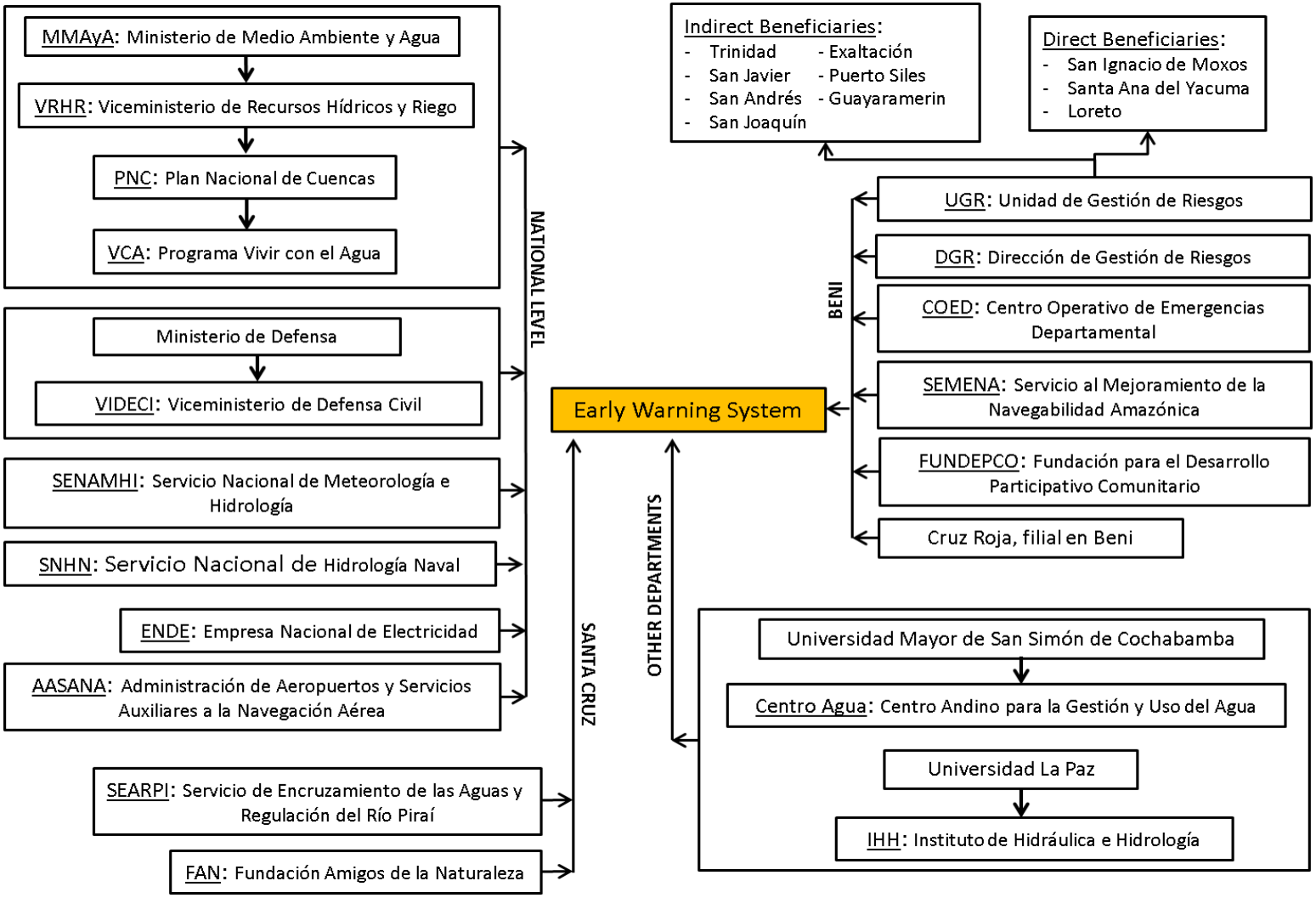

Figure 15: Mapping of stakeholders

5.2.1. Primary stakeholders

The main stakeholders identified for playing an important role in the design and implementation of the new flood Early Warning System are listed and described in this subchapter.

VRHR	
Description: "*Viceministerio de Recursos Hídricos y Riego*" is a public body (vice-ministry) attached to the Ministry of Environment and Water (MAAyA). It is the implementing body of the program "Vivir con el Agua". **Regions:** Headquarters: La Paz However it is a decentralized public body; thereby, the units are distributed throughout the country.	**Warning chain:** VRHR is responsible for the supervision of the design and implementation of the project SAT-Beni. **Capabilities:** The main weakness of the vice-ministry is 'time'. Although there are the appropriate capabilities to supervise the program, the lack of time by the personnel is considerable.

Since 2010, the VRHR, Viceministerio de Recursos Hídricos y Riego, has been under the jurisdiction of the Deputy Minister, Carlos Ortuño. However, it must be noted that during the last few years the Deputy Minister been changed on six occasions. One of the most relevant weaknesses that face the country is the detrimental influence that policy has on all issues, making stability of personnel considerably difficult. Furthermore, the President, Evo Morales, has created the National Assemblies. At local and regional levels, the National Assemblies come together to identify regional priorities. However, since the creation of these National Assemblies the instability of personnel has increased dramatically. The VRHR is the implementing body of the program "Vivir con el Agua". It must be clarified that this project is the basis for the successful implementation of the EWS of this program. The program "Plan Nacional de Cuencas" is the instrument that aims to manage the hydrologic risks. Focusing on the project SAT-Beni, VRHR's priority is the strengthening

of local capabilities in Beni. In order to support the program "Vivir con el Agua" a Program Coordination Unit will be established with a base in Trinidad. This unit consists of a coordinator and 3 or 4 technicians, responsible for the various components of the program. When the project ends, these personnel will then be hired by the DGR, Dirección de Gestión de Riesgos, in order to ensure the sustainability of the program.

SENAMHI-La Paz	
Description: "*Servicio Nacional de Meteorología e Hidrografía*" is the official institution (public body) responsible for the operation of the meteorological and hydrologic network in Bolivia. **Regions:** Headquarters: La Paz Regional offices: each department	**Warning chain:** - Monitoring - Evaluation and forecasting - Notification **Capabilities:** SENAMHI has focused its efforts on strengthening the meteorological unit; however, the hydrological unit has not been supported much by the institution.

SENAMHI has its headquarters in the capital of the country, La Paz. Moreover, each department has its own regional office. This institution is a public body attached to the Ministry of Environment and Water, MMAyA. Instead of having a close relationship with the Ministry, the corruption cases and misappropriation of public funds during the last few years has created a significant degree of distrust and, because of this, the institution is badly weakened. This distrust means that the MMAyA has significantly reduced the funds designated to this institution. Another consequence has been that the MMAyA has been considering the option of eliminating its function of being responsible for the national hydrologic network and instead creating a new institution responsible for hydrology.

This reduction in funds implies that the strategy of SENAMHI to access more funding is in order to participate and develop projects coordinating with international organizations with international cooperation funding. Unfortunately, it is common that when the project ends, the agreements and goals achieved during the implementation of the project disappear. As a result, it has not been possible to date to achieve the middle and long term sustainability of the projects. That seems to me to be one of the most relevant risks of the present project.

SENAMHI has a centralist structure; thereby, all operation and maintenance tasks, as well as, equipment configuration, among other issues are carried out by national SENAMHI staff. This means that a configuration failure, the monitoring stations maintenance, etc. depend on the field visits that are usually carried out 2 or 3 times per year by some operators of national SENAMHI. These intervals between visits mean that the equipment, the monitoring stations, etc. do not always work or have malfunctioned. This problem could be easily solved if regional offices have enough technical and logistical capabilities; however, the actual organizational structure does not allow for such a solution.

In terms of skills, the name SENAMHI means that this institution is responsible for the national meteorological and hydrologic network. The reality is that SENAMHI has focused its efforts on improving the meteorological unit, but the hydrologic unit obtained very little attention. As a result, the equipment, monitoring stations and personnel from the meteorological unit represents around 80% of the budget.

In terms of specific roles, SENAMHI plays an important role in four elements of the warning chain: monitoring, evaluation and forecasting, notification and warning. Referring to monitoring, the meteorological monitoring network is extended throughout the whole country; however, the hydrometrical network is very limited. More specifically, in Beni the number

of hydrometeorological stations is only 5. In relation with the element evaluation and forecasting, the program called SISMET, designed by SENAMHI, is the most effective program for meteorological forecasts. Hence, the capability for doing meteorological forecasts is relatively high. On the other hand, the hydrological forecasts are very limited. The implementation of the project SAT-Beni will strengthen this weakness. However, it must be noted that the strengthening of the informatics will not by itself achieve the middle and long term sustainability of the project, change to the structural organization will also be crucial element.

Thanks to a project funded by Spanish cooperation, that finished in 2011, the most relevant Bolivian institutions have (or should have) constant access to the SENAMHI database through the WAN system, for instance, municipalities, SEARPI, AMDEBENI, etc. However, the current situation is that most of the institutions in Beni do not have access to this information anymore.

Due to the fact that SENAMHI has a centralist structure, the regional offices do not play a decisive roll either in decision making or in operational tasks. The regional office **SENAMHI Santa Cruz** has a team of 3 persons: a secretary, a technical expert, who is responsible for writing the measurements taken by the operators to the SISMET database and the director. However, during the implementation of the WAN communication project funded by Spanish cooperation, the working team was increased by two additional technicians.

Unlike other regional offices, SENAMHI Santa Cruz maintains close relations with SENAMHI La Paz, the headquarters. This means that the WAN communication system is still working despite, significant internet problems. Nevertheless, although the communication between both offices has not been broken, SENAMHI Santa Cruz is not able to operate and maintain the

monitoring network. The lack of budget, personnel and equipment, as well as, the structural organization of SENAMHI impedes the ability of the regional office to carry out these tasks. Moreover, unlike other regional offices, SENAMHI Santa Cruz does not take part in evaluation and forecasting, it is only responsible for the monitoring element.

Finally, although before the coordination agreement of DGR, SENAMHI and SEARPI, the institutional relationship between SENAMHI La Paz and SEARPI was completely broken, there were still some contacts between SENAMHI Santa Cruz and SEARPI.

SENAMHI Beni is one of the most disadvantaged regional offices in terms of equipment, personnel and interinstitutional communication. This regional office has been completely isolated from the rest of SENAMHI's offices for a year. The regional office SENAMHI Beni has a team of 2 persons: a secretary and the director. It must be noted that in 2011 when the implementation of the WAN communication project funded by Spanish cooperation took place, a meteorological technician was hired to work in SENAMHI Beni, Hugo Mamani (see interview in Annex 3). Unfortunately, the end of the project resulted in the dismissal of this expert. It was then that the DGR hired him as technical expert within the field of meteorology at the SAT unit with funding from the departmental government. As a result, SENAMHI Beni is nowadays a regional office without any capacity for taking action or decisions because it does not receive national support.

SENAMHI Cochabamba is, in comparison with the other two regional offices analysed in this MSc Thesis, the regional office that receives the greatest support from national SENAMHI. The working team is composed of 5 members: three technicians (of whom, one is the director) and two secretaries. More specifically, there is one expert

responsible for the meteorological forecasts and who has periodic contact with the operators from the monitoring stations. There is one expert responsible for the database and finally, there is the director who supervises forecasts.

As SENAMHI Santa Cruz, SENAMHI Cochabamba maintains close relations with SENAMHI La Paz, their headquarters. For example, the WAN communication system is still working, in spite of the significant internet problems. Unlike other regional offices, SENAMHI Cochabamba has suitable logistics equipment to carry out the operation and maintenance of some monitoring stations in their department. This regional office focuses on four elements of the warning chain: monitoring, evaluation and forecasting, notification and warning. The most relevant strength of EWS Cochabamba, which can be used as a basis for the design and implementation of the EWS in Beni, is that although the dispersion of the monitoring network is considerable as in Beni, SENAMHI has achieved the configuration of a solid monitoring network that allows reciprocal transmissions. This approach has been possible thanks to a rigorous analysis of the interests and needs of the stakeholders.

<table>
<tr><th colspan="2">SEARPI</th></tr>
<tr>
<td>Description: “Servicio de Encauzamiento de Aguas y Regularización del río Piraí” is the departmental institution in Santa Cruz based in the capital of the department. It invests in prevention and Flood EWS. Their knowledge is focused on both rivers: Río Grande and Río Ichilo, rivers from the Mamoré river basin.

Regions:
Headquarters: Santa Cruz de la Sierra</td>
<td>Warning chain:
- Monitoring
- Evaluation and forecasting
- Notification

Capabilities:
The most valuable asset from SEARPI is their EWS, the most effective Flood EWS in Bolivia. Almost 30 years of experience in the EWS are the best guarantee of leadership in this field.</td>
</tr>
</table>

SEARPI is the departmental institution in Santa Cruz which accounts for 93 persons as direct personnel. Although originally SEARPI's work area was just the Piraí river basin, nowadays it has an extensive monitoring network that extends across five river basins including Río Grande and Río Piraí. This institution receives funding mainly from the departmental government; however it is also involved in some projects that receive international cooperation funding. In terms of SEARPI's roles within the field of EWS, it plays an important role in four elements of the warning chain: monitoring, evaluation and forecasting, notification and warning.

In terms of flood EWS, SEARPI has developed the most effective EWS in Bolivia. It must be noted that this effectiveness has been achieved thanks to the institutional and economic support of the Santa Cruz government. SEARPI is the strongest institution in Santa Cruz in terms of monitoring, forecasting and EWS in general. In Santa Cruz, other institutions like SENAMHI, SNHN (*Servicio Nacional de Hidrografia Naval*), amongst others, have little or no presence within this department.

The effectiveness of the EWS Santa Cruz is based on three pillars, the monitoring network; a proper communication system both internally and externally and finally, a simple but also an effective forecasting system based on years of experience.

DGR/COED Beni	
Description: "*Dirección de Gestión de Riesgos" together with "Centro Operativo de Emergencias Departamental"* are leaded and coordinated by Luis Phillips and funded by the regional government. While DGR operates throughout the year, COED is an intersectorial organization that coordinates the emergency preparation and response. **Regions:** Headquarters: Trinidad, Beni	**Warning chain:** - Monitoring - Evaluation and forecasting - Notification - Decision Making - Warning - Response **Capabilities:** DGR and COED have focused their efforts on developing and then strengthening a EWS based on the accumulated experience of Luis Phillips.

The DGR depends directly on the GAD Beni, the regional government; however, the director of this institution is Luis Phillips. DGR is responsible for the disaster risk management during every day of the year, including all kind of disasters, for instance, drought, flooding, the control of the spread of infectious diseases such as dengue fever, managing wildfire, etc. However, COED is only activated when emergency preparation and response is required due to an imminent event. Instead of DGR, the director of COED is the governor of the department. This implies that the decision making before the warning dissemination is carried out by the governor. Figure 17 shows a schematic view of the specific roles of both institutions DGR and COED referring to the warning chain.

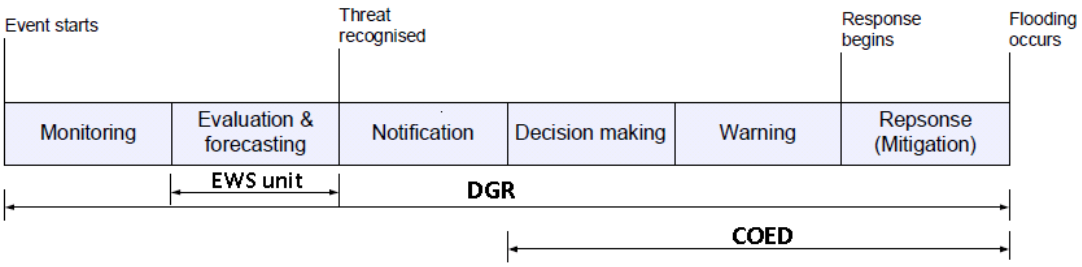

Figure 16: Roles of DGR and COED Beni

SEMENA	
Description: "*Servicio al Mejoramiento de la Navegación Amazónica"* is a descentralized public entity attached to the Ministry of Public Works, Services and Housing. SEMENA working members used to be technicians; however, in 2006 the Ministry decided that it should be headed by Marines. **Regions:** Headquarters: Trinidad, Beni	**Warning chain:** - Monitoring **Capabilities:** SEMENA has established a solid monitoring network in the Amazon basin. Moreover, it aims to develop a system that forecasts the flood peaks of the Mamoré river adapted to navy needs.

SEMENA is a public body attached to the Ministry of Public Works, Services and Housing. Although there is a good working relationship between both entities, the fund that SEMENA receives is little. However, after the field research it can be concluded that the monitoring network from SEMENA in terms of sustainability is the most effective in the department of Beni.

FUNDEPCO	
Description: "*Fundación para el Desarrollo Participativo Comunitario*" focuses on risk management, planning, education and emergency response through humanitarian aid. **Regions:** Headquarters: La Paz Regional office: Trinidad, Beni	**Warning chain:** - Response **Capabilities:** FUNDEPCO can bring the experience gained from many years working in disaster risk management at regional and municipal level, for example through training of local people and development of the current EWS in Beni.

This foundation developed the Project "*Prevención, Preparación y Mitigación de Desastres de Origen Natural en la Cuenca del Río Mamoré*" in the departments of Cochabamba and Beni. While the municipalities involved in Beni are Trinidad, San Ignacio de Moxos and Loreto, Puerto Villarroel, Chimoré and Villa Tunari are the municipalities located in Cochabamba. This project is the baseline of the socio-economic conditions, resources, vulnerability and hazard maps. Moreover, it also developed the Project DIPECHO VI "*Implantación del Sistema de Alerta Temprana y Preparación ante Desastres en el Departamento del Beni – Bolivia*".

5.2.2. Secondary stakeholders

The other relevant stakeholders that need to be considered in the design and implementation of the new flood Early Warning System are briefly described in this subchapter.

VIDECI: "Viceministerio de Defensa Civil" of the "Ministerio de Defensa" through SENADECI (Servicio Nacional de Defensa Civil) has the responsibility for relief disasters that occur in Bolivia through preparation, warning management and coordination of response and recovery.

IHH: "Instituto de Hidráulica e Hidrología" of La Paz university is an institute with experience in hydrologic modelling using the HEC-HMS.

AASANA: "Administración de Aeropuertos y Servicios Auxiliares a la Navegación Aérea" is responsible for the control and protection of air navigation in the Bolivian airspace. Its mission includes the hourly monitoring of the airports using meteorological stations.

FAN: "Fundación Amigos de la Naturaleza" promotes biodiversity conservation in Bolivia. Some studies of the movements of

flood waves in the Mamoré River have been carried out by this institution.

AMDEBENI: "Asociación de Municipios del Beni" provides advice to all municipalities in Beni. The direct beneficiaries of the Project "*Desarrollo e implementación del SAT-Beni*" are the municipalities Santa Ana del Yacuma, San Ignacio de Moxos and Loreto. However, Trinidad, San Javier, San Andrés, San Joaquín, Exaltación, Puerto Siles and Guayaramerin are indirect beneficiaries.

CAN: "La Comunidad Andina" together with CAPRADE (Comité Andino para la Prevención y Atención de Desastres) developed the Project PREDECAN "*Prevención de Desastres en la Comunidad Andina*". This organization has great knowledge about response in extreme situations. In Beni this organization in conjunction with FUNDEPCO, amongst others, developed the Project DIPECHO V "*Plan de Gestión Local del Riesgo. Proyecto Piloto Participativo en Gestión Local del Riesgo de Desastres en el Municipio de San Borja*".

OXFAM: This organization developed in conjuction with FUNDEPCO and CAN the projects DIPECHO VI and "*Plan de Gestión Local del Riesgo. Proyecto Piloto Participativo en Gestión Local del Riesgo de Desastres en el Municipio de San Borja*".

Red Cross (in Beni): This organization developed the Project "Fortalecimiento de las Capacidades Locales para la Prevención y Respuesta a desastres Naturales de 10 Comunidades" which focuses on emergency preparedness in the municipality of Santa Ana de Yacuma. It also developed a project based on the implementation of a EWS in the municipalities: Santa Ana del Yacuma, San Ignacio de Moxos, San Javier, Trinidad and San Ramón.

FAO: This organization developed hazard maps in Beni and Potosí. It has implemented the current EWS in the

municipalities of San Andrés, San Javier, San Ignacio de Mojos, Santa Ana, San Joaquín, San Ramón, Puerto Siles and Exaltación.

Save The Children: This organization has spear-headed the implementation of the project DIPECHO "*Preparación para las Inundaciones de la Cuenca del Río Mamoré*" in 30 communities in the municipalities of Trinidad, Loreto, San Ignacio de Moxos in Beni and in Villarroel and Chimoré in Cochabamba. This organization has also developed an emergency plan for the education community.

OPS/OMS: This organization developed together with Save The Children among others the project DIPECHO "*Preparación para las Inundaciones de la Cuenca del Río Mamoré*".

CARITAS: This organization plays an important role in the preparedness and response during natural disasters. They participated in the Project DIPECHO by analysing the perception of risk by citizens and improving their preparedness through training courses and workshops in Beni (Ballivián), La Paz, Cochabamba and Santa Cruz.

CPIB and CMIB: Both "Central de Pueblos Indígenas del Beni" and "Central de Mujeres Indígenas del Beni" of CIDOB (Confederación de Pueblos Indígenas de Bolivia) have a leading role to play in decision making. Due to the fact that the woman's role is usually as primary resource user and manager, it is important to make women essential partners in defining the possible improvements of the EWS. Therefore, CMIB is included in the stakeholders list.

FEGABENI: "Federación de Ganaderos de Beni y Pando" is an organization established by the cattle growers located in Beni and Pando. This organization aims to promote cattle development in these regions.

Education community: The improvement of the existing EWS needs to include the education community as they are partly responsible for disaster preparation and response. CAN organized a workshop in 2008 in Cochabamba with participants from the departments of Beni, Pando, Cochabamba and Santa Cruz ("*Taller de Capacitación de Docentes para la Educación en Gestión del Riesgo*").

SAR-FAB-Beni: "Grupo Especial de Búsqueda y Rescate" is an important organization for implementing the response to warnings. They are specialized in the emergency rescue of citizens.

5.3. Roles and Responsibilities

Identifying stakeholder roles aims to give a more detailed view, not only of the stakeholders involved but also of the institutional relationships. The categorization of the specific roles has been carried out using the elements of the warninh chain explained in chapter 4. These elements are considered as the most appropriate basis for implementing and analysing the existing EWS in Beni. Thus, the stakeholders involved within the current EWS in the department of Beni have been categorized in Figure 17 according to their roles within the element(s) of the warning chain.

The current EWS Beni assumes that municipalities should play a major part in decision making based on their knowledge of local conditions; even though, local capabilities are extremely limited. In addition, another important weakness has been identified when analysing the current system which is that in a large part of the municipalities (UGRs), among other institutions, responsibilities are not defined. On the basis of these weaknesses it is critically important to state the roles and responsibilities for each type of group or

institution in order to achieve an efficient and sustainable strengthening of the current EWS in the department of Beni. Minimizing decision-making processes and establishing clear fields of responsibility will also help tighten up procedures and create the right conditions for a more flexible, faster response when an event occurs.

The mapping of stakeholders shows that a vast number of stakeholders are considered to be part of the current EWS in Beni, and not only the stakeholders that were known before the field work. Analysing the results, it can be observed that most of the institutions are concentrated on the monitoring and response elements of the warning chain. Due to the fact that the responsibilities of the stakeholders involved in the monitoring element are well known (and this element is described in detail in chapter 6), a brief description of the stakeholders responsible for the response within the current EWS and their roles is described in Figures 18 and Figure 19.

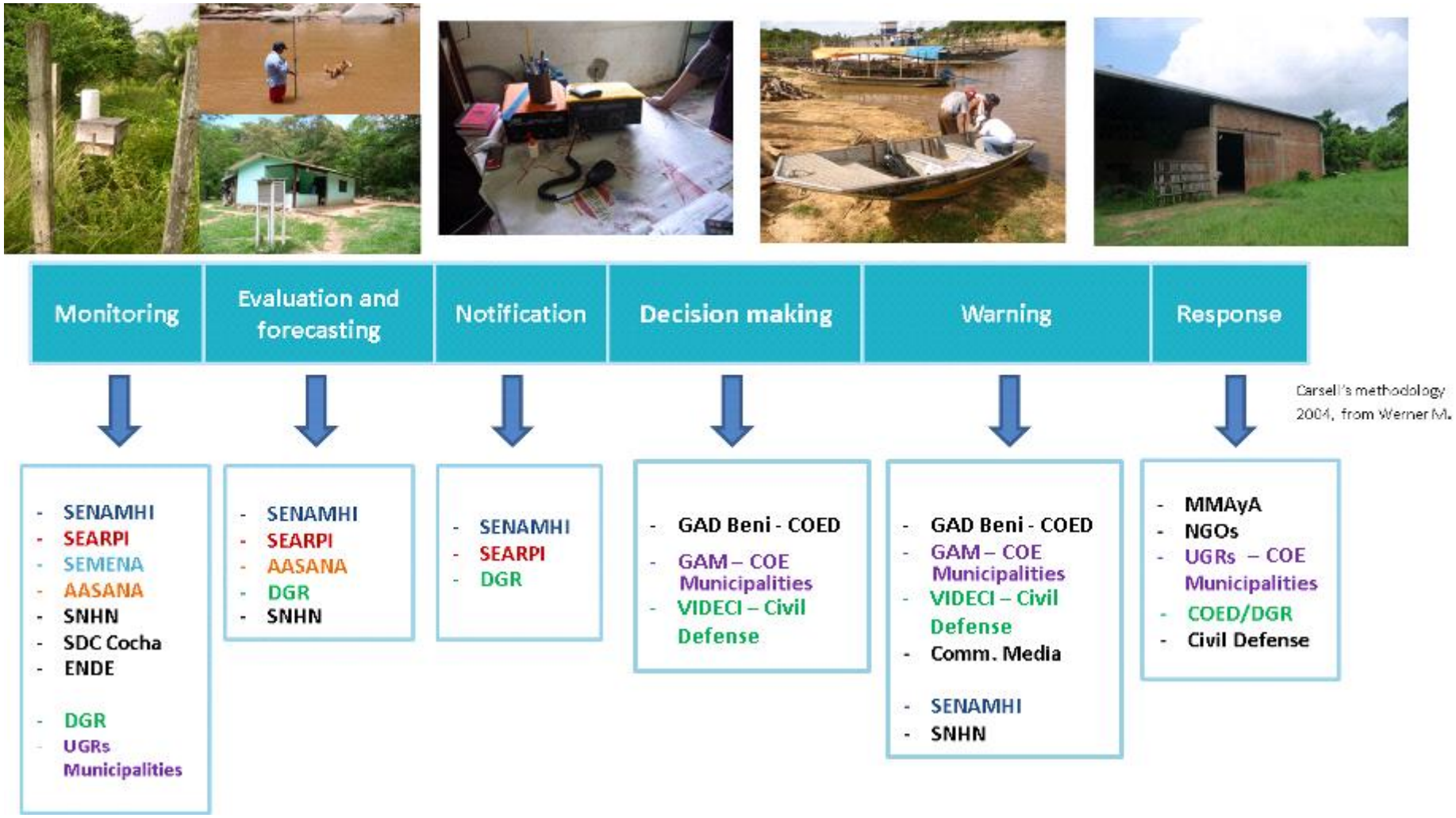

Figure 17: Specific roles of the stakeholders involved within the current EWS Beni, Cochabamba and Santa Cruz

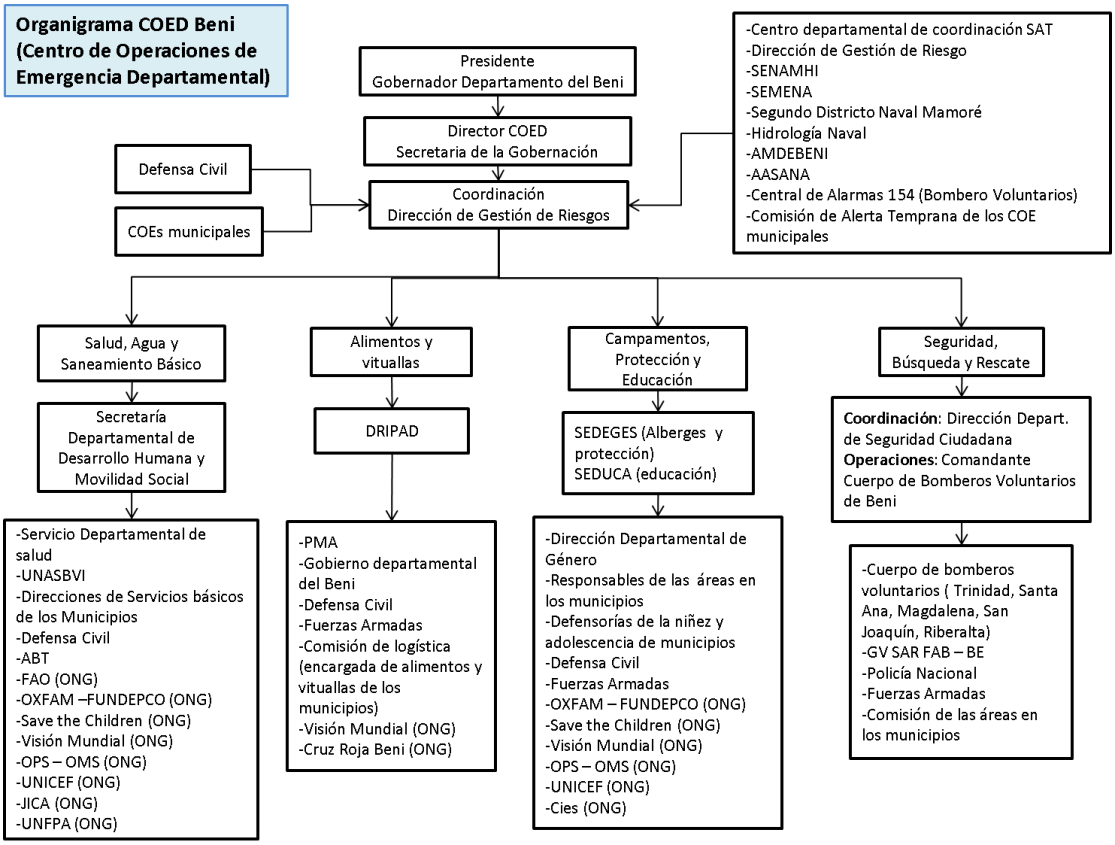

Figure 18: Roles of the stakeholders involved in the EWS response in Beni

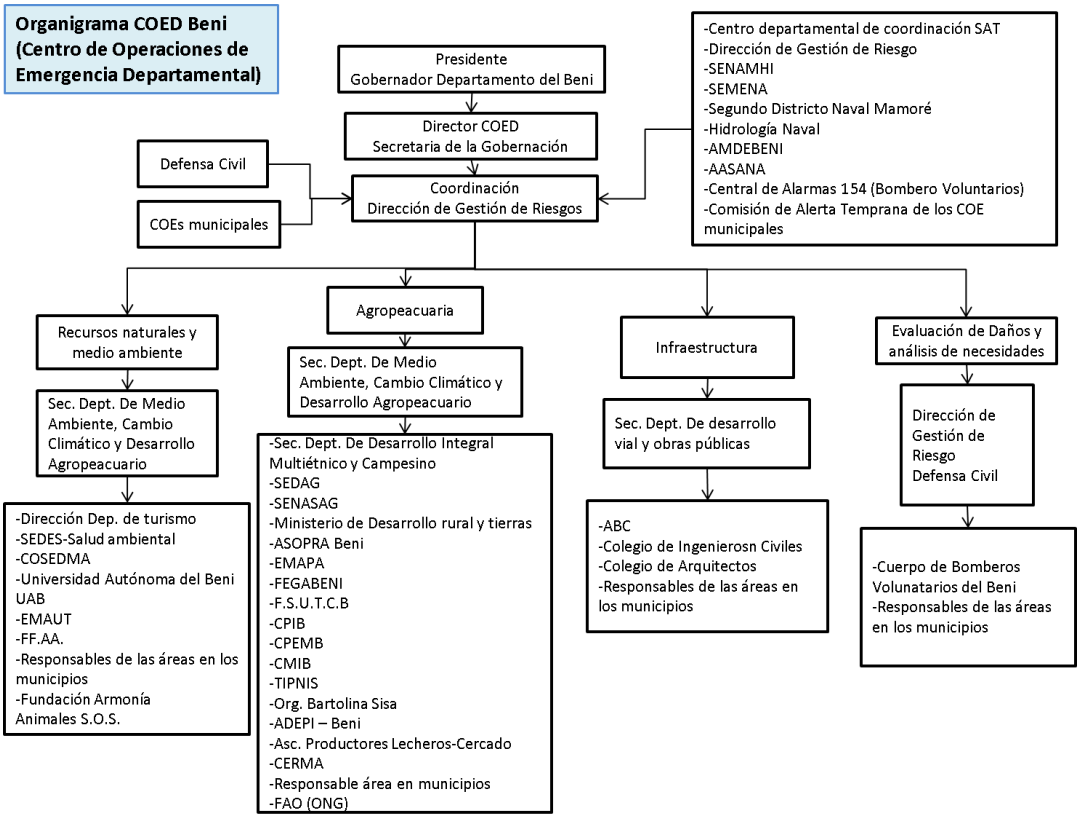

Figure 19: Roles of the stakeholders involved in the EWS response in Beni (2)

5.4. Interests and needs

Due to the crucial importance of involving stakeholders in the design and implementation of the flood EWS in the department of Beni, the interests regarding disaster risk reduction including Early Warning Systems and the specific needs of the relevant stakeholders have been obtained from interviews and group discussions. The needs classified according to the elements of the warning chain together with the interests are shown in Table 5.

Stakeholders	Interest	Needs
	-	-
		-

Table 5: Stakeholders interests and needs analysis

5.5. Dependences

The relevant stakeholders involved in the issue of flood EWS in Beni have been classified in Figure 20 according to whether they are governmental, private or social organizations. The non-organized interests of groups like the citizens from the municipalities involved within the project, have also been taken into account. In order to identify the dependencies of the stakeholders for the flood EWS in Beni based on their capabilities, roles, interests and needs, the organizations and institutions have been colored according to their participation in the first workshop that took place in Trinidad in November 2012. The presence at the event shows the initial interest of stakeholders in this project. This assessment can be a useful tool to consider dependence analysis.

The stakeholders colored in green are stakeholders that had been identified by the consortium as principal stakeholders involved within the EWS in Beni before the workshop took place and they were also participants. Stakeholders that did not participate in the workshop, but were invited by the ministry and the consortium, are colored in red. Finally, those organizations and institutions that were not initially identified as stakeholders involved within the flood EWS by the consortium but during the workshop in Trinidad were identified by other national and regional stakeholders are colored in yellow.

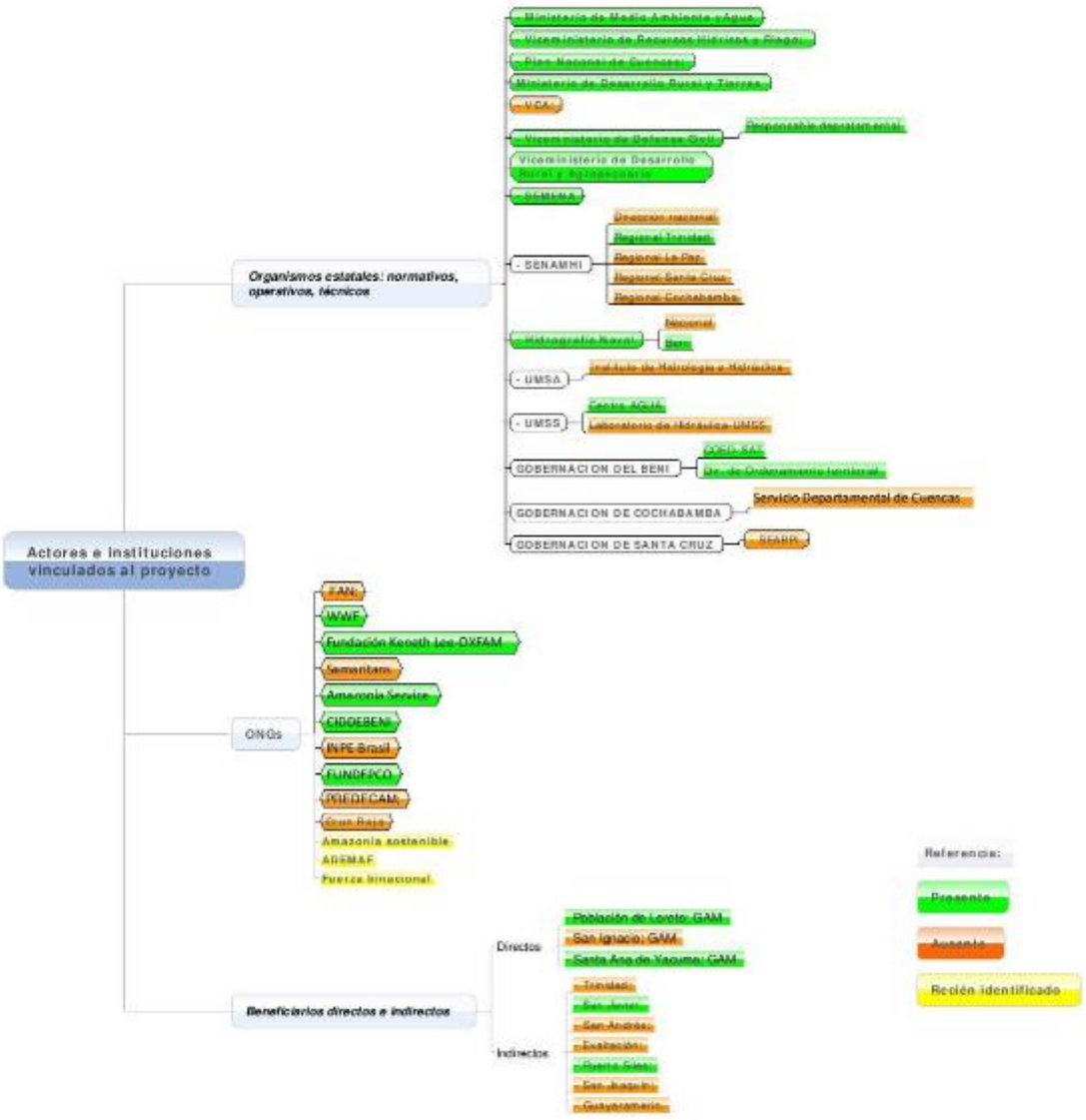

Figure 20: Categorization of stakeholders

Based on interviews with the main stakeholders about each other's positions, written documents, the results from the workshop that took place in Trinidad in November 2012 and the estimation of positions, perceptions and interest based on my own knowledge, stakeholders have been classified according to their dependencies in Table 6. The first classification is the nature of stakeholders; the second classification is according to their roles, capabilities, needs and interests. It must be noted that positions of stakeholders may not always have crystallized and may change over time.

	Dedicated stakeholders		Non-dedicated stakeholders	
	Critical stakeholders	Non-critical stakeholders	Critical stakeholders	Non-critical stakeholders
Similar needs, interest and objectives	MMAyA/VRHR SENAMHI SEARPI DGR/COED	SEMENA SNHN AASANA UGR St. Ana UGR S. Ignacio GAD Beni	GAM Loreto ENDE	FAN UGR indirect beneficiaries NGOs SDC Cocha. Com. Media
Different needs, interest and objectives			FUNDEPCO	Amazonia Sostenible Fund. Kenneth Lee NGOs

Table 6: The schematic field of actors

Referring to Table 6, SENAMHI together with DGR/COED are the critical stakeholders that play an essential role and during some interviews and meetings, it became apparent that their needs, interests and objectives are quite similar to those of the Viceministerio de Recursos Hídricos y Riego, VRHR, and of the international consortium.

Literature[69] points out the relevance of participation within flood Early Warning Systems. More specifically, it advocates the creation of space for participation and raising awareness amongst all stakeholders, including, volunteers, governance and administrative personnel, experts, disaster managers, etc. However, the involvement and importance of stakeholders differs from one to the other, depending on their role in the project as critical or non-critical stakeholders. Hence, four sorts of participation mechanisms can be implemented to identify the strengths and weaknesses of the current EWS and to establish the basis for strengthening the system. The choice of the participation mechanism depends on the importance of organizations within the project. The four participation mechanisms are:

[69] UNISDR, 2004

Instrumental: This kind of participation mechanism allows for a minimum level of influence in decision making. The program or project integrates the offer of participation through corresponding institutional channels. Since the flow of information is one way, participants can only make a very restricted description of their needs. The aim of this participation mechanism is to extract information from the participants.

Consultative: This kind of participation mechanism combines minimum influence on decision making with identification of the participants' needs. There are channels, or if not already existing, channels are generated to receive the participants' opinions and positions on a certain issue. The consultation can be binding or non-binding.

Managerial: This kind of participation mechanism permits greater influence on decision making but only offers a limited satisfaction of the needs expressed. The stakeholders are considered managers and/or implementers of programs or projects. The stakeholders participate in the negotiation process, which leads to binding agreements and hence, have an impact on the decision that is made, although these benefits do not necessarily translate into the satisfaction of needs.

Empowerment: This kind of participation mechanism combines the maximum level of influence on decision making with optimal satisfaction of demands. The community develops skills and abilities, reinforces its spaces and organizations and acts with a sense of its own identify and community. The strengthening of organizations and the work in networks make for efficient action focused on fulfilling goals and projects.

6. FEWS – Assessment and recommendations

This chapter provides some short and long term recommendations for improvements to the current flood EWS in the department of Beni. An analysis of the current flood EWS implemented in Beni is carried out based on the premise that producing decisions and actions in order to achieve the effective design and implementation of a flood EWS and make it sustainable in the middle and long term requires the formulation of problems and the search for solutions based on organization participation, the creation of ideas for strategic interventions[70].. The analysis includes the description of the warning system in terms of monitoring networks, forecasting systems, types of warnings, warning information dissemination network, communication methods and flood responses. As with the stakeholder analysis, the data to assess the existing EWS has been collected through interviews and discussion sessions with professionals in the relevant local, regional and national level, and also with citizens who live within communities at risk. Moreover, specific national and regional protocols are crucial to the literature review to achieve a proper identification of the strengths and weaknesses of the warning system. The combination of both assessment methodologies allows the comparison between both theoretical and practical frameworks. Based on this premise, this chapter aims to respond to the following research questions:

- *What are the strengths and weaknesses of the existing Early Warning System?*

- *What are the recommendations for the design and implementation of the new flood Early Warning System considering the needs of the stakeholders?*

The flood Early Warning System in the department of Beni has a high degree of complexity, given the large number of

[70] Bryson J., 2004

stakeholders involved with similar roles and functions. Figure 21 displays the communication network of this warning system. This diagram makes a distinction between the stakeholders that play a role in the field of flood EWS at national, regional and local level. It also differentiates between the elements that compose the warning chain. Hence, a precise view of the stakeholders involved including their functions is obtained. Furthermore, this diagram gives information about the flood warning information dissemination network including the technologies currently used.

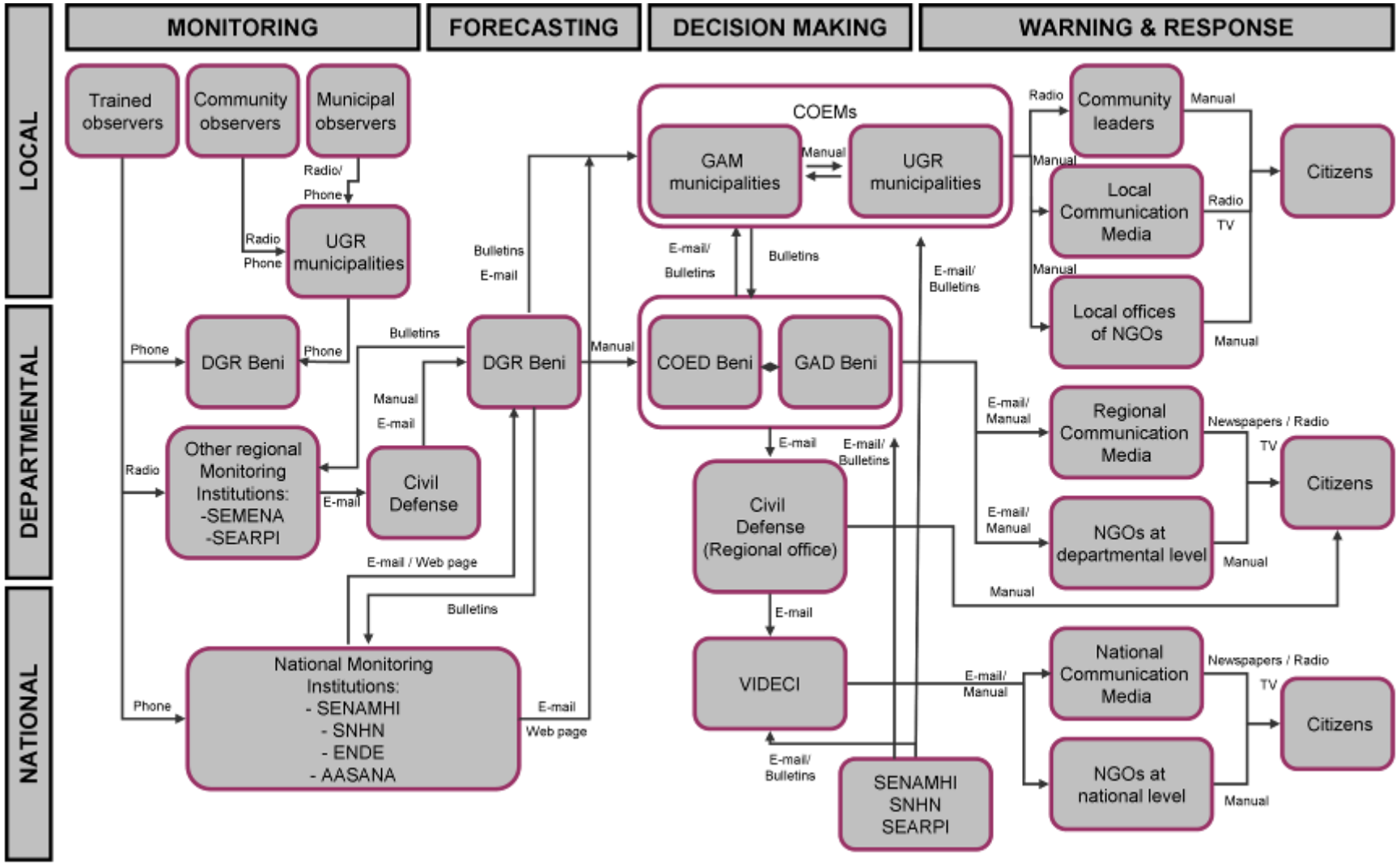

Figure 21: Warning information dissemination network

6.1. Monitoring and forecasting

Although the administration and management functions of regional flood EWS are commonly centralized in the national headquarters, Bolivia and particularly the department of Beni is an exception. Several institutions have similar responsibilities. In terms of monitoring and forecasting, SENAMHI, AASANA, ENDE, SNHN are the competent authorities at national level. In the department of Beni, SEMENA is the responsible authority. However, SEARPI is also involved due to its flood EWS in Santa Cruz de la Sierra, as well as, S.D.C. Cochabamba in its department. Focusing on the dissemination of information, a variety of forecasts bulletins are produced by the regional and national institutions.

Particularly, SENAMHI produces daily meteorological forecasts bulletins and disseminates these through their web site, through e-mail and through its own WAN communication system to relevant government agencies, communication media, NGOs, amongst others. Forecast bulletins diverge between the national headquarters and regional offices. Forecast bulletins contain general information which is sent via e-mail; whereas, regional offices produce meteorological forecasts bulletins with a forecast lead time of three days and adapt the information to users. In the case of SENAMHI Cochabamba, this regional office adapts the meteorological information to specific farmers' interests.

However, SENAMHI is not the only institution that monitor and/or develop forecasts, SNHN is also responsible for monitoring several river basins in Bolivia but the monitoring information is adapted to navy interests. The hydrological information is disseminated through weekly bulletins available on their web site. More specifically, their bulletins available on their web pages contain historical and actual measurement data from the main rivers of the country.

Moreover, port authorities receive daily updated hydrological information through a dedicated radio frequency. The information of measures is reported according to the navy's particular requirements. This includes water levels including the specific danger water levels of each main river. Although several organizations have similar functional roles and work independently with limited coordination between them, they all assume the same four danger levels within the flood EWS: green, yellow, orange and red. However, warning ranges differ significantly. Figure 22 displays the different warning levels. In addition, the methodology used by SNHN to measure water levels is displayed.

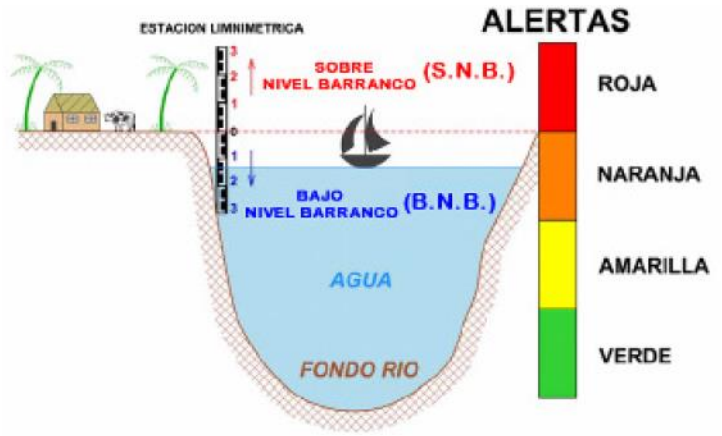

Figure 22: Warning levels

ENDE also monitors some river basins at national level, typically those where hydroelectric power plants are located. However, data is not publicly available. In the case of AASANA, they have an extended monitoring network consisting of meteorological stations located at each main and regional airport. This institution produces daily forecasts bulletins with a forecast lead time of two weeks being available on their web site.

Figure 23: Meteorological station in Trinidad from AASANA

At regional level, SEMENA controls and manages the Amazon river basin by monitoring the main rivers through hydrometric stations. SEMENA adapts monitoring information for navigation interests. Daily hydrological information is transmitted to navigators through a dedicated radio frequency, to regional authorities via e-mail and is publicly available on their web page.

Figure 24: Hydrometric station in 'Puerto Almazén' from SEMENA

SEARPI is the strongest institution in Santa Cruz in terms of monitoring, forecasting and notification. In general terms, this institution has developed and implemented the most effective flood EWS in Bolivia. Although other institutions have some presence in this department, SEARPI has the most extended monitoring network based on hydrometeorological stations located in five river basins: Piraí, Grande, Surutú, Yapacaní e Ichilo. Information about the rise or fall of water levels is updated every two hours and is publicly available on their web page. Moreover, once the data is evaluated and the forecasts are obtained, the information is notified to the departmental and provincial governances, municipalities, COED Santa Cruz (*Centro de Operaciones de Emergencias Departamental*) and regional communication media.

Figure 25: Hydrometeorological station in 'Angostura' from SEARPI

It must be noted that DGR and UGRs of the municipalities are not specifically responsible for monitoring the river basins located under their jurisdiction; however, regional and local institutions consider that owning monitoring stations is necessary in the interests of greater accuracy of the hydrometeorological forecasts. This need is the direct consequence of the low quality of monitoring data that result in inaccurate forecasts being produced by mostly national organizations. In the case of DGR Beni, daily meteorological forecasts bulletins, with a maximum forecast lead time of three days, are produced and the information is disseminated

through e-mail to the UGRs from the municipalities and other regional organizations, for instance, SEMENA. Hydrological forecasts are also daily elaborated upon and disseminated via phone.

By analyzing the local situation regarding the existing Early Warning System in the department of Beni, several shortcomings have been identified and it is clear that one of the main problems lie in the lack of participation and coordination by the stakeholders. In addition, it can be observed that failure in the interinstitutional communication and coordination between those stakeholders with similar roles, on the basis of their strong competiveness, has a negative impact on the success of the monitoring and forecasting and thus, on the entire warning chain. Moreover, the various hazards are dealt with by separate and independent technical institutions, with few mutual benefits being sought. Hence, the coordination among these institutions is limited. The consequence of this lack of coordination between the stakeholders involved in monitoring and forecasting affects other stakeholders interested in other fields of the warning chain and disaster risk management, including those citizens who live in flood-prone areas.

Figure 26 reflects the stakeholders that should be considered when the development of the new flood EWS, as well as, their specific roles. A distinction must be made between the primary and the secondary stakeholders. On the one hand, SENAMHI, SEARPI, DGR, SEMENA and AASANA play an important role in the improvement of the current warning system and in the development of the new system. On the other hand, SNHN, ENDE and UGRs from municipalities must be also considered and their needs should be taken into account, but they are not critical stakeholders.

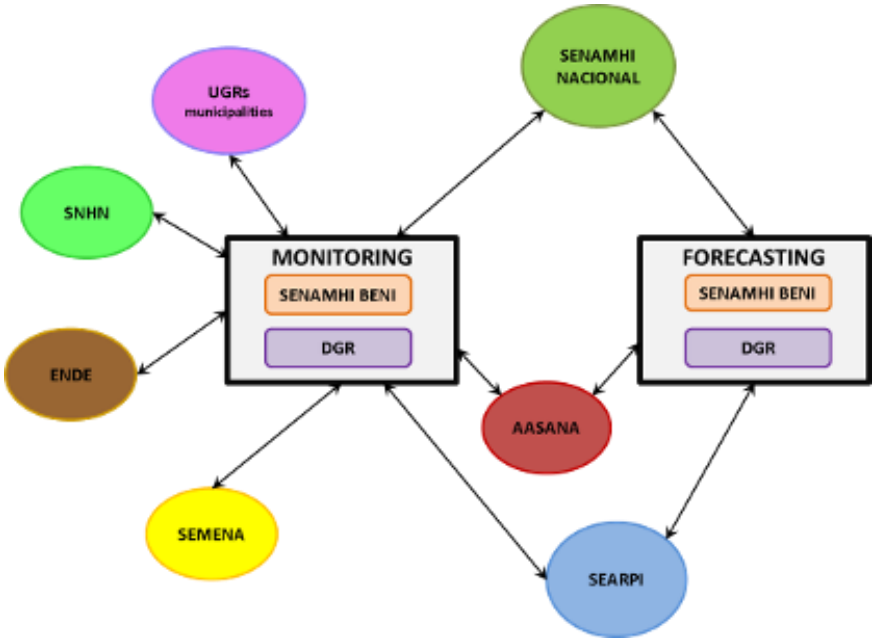

Figure 26: Recommended organizational structure for monitoring and forecasting

The existing monitoring network has also an important weakness in the O&M, resulting in a low quality of data. This has negative consequences when elaborating forecasts. In order to ensure the effectiveness of the monitoring network, the quality of monitoring data and the forecasts, emphasis has to be put on the sustainability in the middle and long term, which means that operators and observers should become a liveable wage, instability of staff should be reduced, funds for O&M and logistic and communication equipment should be increased, amongst others. Moreover, a proper diagnostic of the existing monitoring network should be carried out by an independent consultant in order to have a clear idea of the status of the stations and the specific needs.

Figure 27: Monitoring stations in Santa Ana and in Cochabamba

Most warning systems put their focus on the hazard itself and because of this, both monitoring and forecasting are considered to be the main elements of the warning chain without taking into account the involvement of the main stakeholders in the development of the forecasting systems. Moreover, when developing and improving the system, little or no emphasis is put on the other elements of the warning chain. More specifically, these traditional forecasting systems, called model centric, are commonly built around the existing model. However, one important disadvantage is that they focus on running the model without a clear understanding of how the lead time provided fits with the information required by each stakeholder. As a result, a high number of projects based on this type of Early Warning Systems carried out in Bolivia and

worldwide have been unable to achieve sustainability over the long term.

The implementation of Delft-FEWS using hydrological forecasts and the adaptation of the forecasting information to customization needs brings benefits firstly to decision makers and secondly to other local stakeholders including those citizens who live flood-prone areas. As trust in the warning information is regained, this has an important impact on citizens' feelings and therefore on their preparedness to act when the threat of an event is communicated.

As remind, the methodology acquired to analyze the flood EWS in Beni is composed of six main elements including monitoring, evaluation and forecasting, notification, decision making, warning and, finally, response. Within these six elements, Delft-FEWS focuses on monitoring and forecasting. Although forecasting techniques, used in the current EWS in the department of Beni, are working properly based on the accumulated experience; the process of automation is necessary in order to increase the available lead time and ease the load on employees.

The monitoring and warning service has the main objective of providing forecasts for a single basin with the purpose of offering guidance for making decisions in order to take action when a natural disaster is expected to occur. Apart from the accuracy of the forecasting results, the success of the entire EWS also depends on whether the forecasts and warning information are clear and usable to stakeholders, including decision makers and end-users, and whether the appropriate response has been carried out.

Instead of providing forecasting capabilities in the form of hydrological modeling algorithms, Delft-FEWS is a hydrological forecasting and warning system based on a platform through which operational forecasting systems can be constructed,

allowing for the integration of models and data. It provides the required input data and parameters, executes the model and reads the results. It must be noted that this forecasting system does not contain inherent hydrological modeling capacities within the code base, but it depends on the integration of modeling components. As a result, its flexibility permits the adaptation of the existing knowledge through interaction of existing models and methods already used in the specific region where it will be implemented.

The Delft-FEWS architecture is a collection of functional modules that communicates with the database exclusively through the data access layer. Furthermore, there is no direct communication of data between modules: for each step the required inputs from the database are retrieved, a functional step is applied and the data are returned to the database for use in subsequent steps. Some of the functional modules included in the architecture of the system are: data import and export modules; general purpose modules, which include transformation and interpolation among others; a general adapter module, which includes linking external models and user interface.

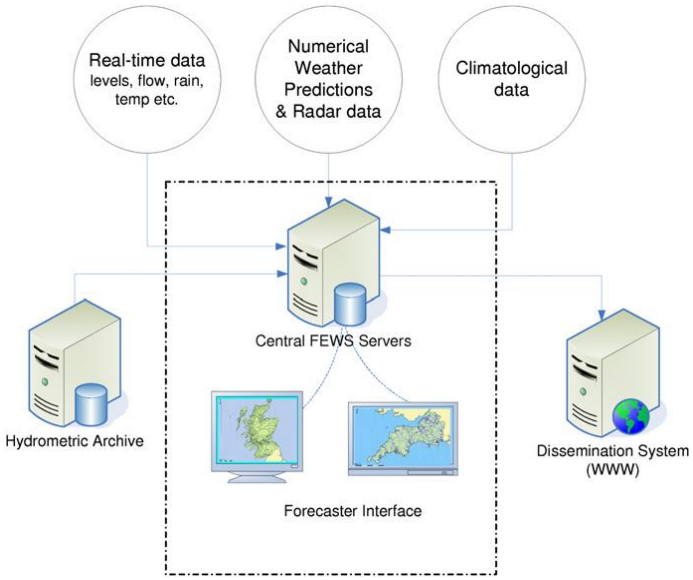

Figure 28: Schematic structure of a flood forecasting system, showing the position of Delft-FEWS

Figure 28 shows the position of Delft-FEWS within the structure of a flood forecasting system[71]. The forecasting system integrates real-time hydrological and meteorological data from acquisition systems. Climatological and reference information, as well as archived data are also crucial input data because they provide supplementary information to the forecaster and can be used to verify the forecasts. The data, which are used for analyzing the hydrological situation, must be processed to an appropriate spatial and temporal scale in order to be used as the input to hydrological and/or hydraulic models. Running the model(s), the future hydrological variables can be provided. Finally, the prediction results are generated and then disseminated to the warning process. Different forms of product generation are available using this forecasting system. Based on HTML templates, Delft-FEWS is able to generate web reports with graphs, tables and summary reports. Alternatively, time series in a threshold of formats, for instance, XML can be obtained as output data.

Due to the fact, that the main goal of this MSc Thesis is to improve the existing EWS for flooding using a stakeholder involvement approach, the user interaction module is described in more detail because appropriate communication is an essential element for the development of an optimal Flood Early warning System. This element includes the communication between Delft-FEWS and a forecasting centre and the communication of the predicted results to the decision makers. The user interfaces allow the interaction between the day-to-day operation of an operational forecasting centre and Delft-FEWS. The design of these interfaces permits an efficient access to the large amount of data that need to be consulted as the basis for the forecasting. All forecast tasks are carried out on a central server. However, in order to decrease the overload of communication, the models are run on the local

[71] Werner M.G.F., Schellekens J., Gijsbers P., van Dijk M., van den Akker O. and Heynert K., 2012

user's workstation when in interactive model. The flexibility of the Delft-FEWS design is a top requirement for effective communication with the decision makers. This flexible design enables the customization of the tools and results to the specific requirements of each individual organization. The results are communicated to decision makers for viewing and based on the obtained results the warning may be activated. Table 7 shows the required lead times by each relevant stakeholder involved in the flood Early Warning System.

Forecasts	Lead time	Variables of interest	Stakeholders
Short range	0 – 10 days	• Water levels • Discharges	• Flood response agencies like DGR-COED, UGRs- COE Mun. and NGOs • Cattle ranchers
Medium and extended range	5 – 10 days 1 – 3 months	• Expected water levels • Expected discharges • Volumetric forecasts	• Flood response agencies (preparedness) like DGR-COED, UGRs- COE Mun. and NGOs • Farmers • Cattle ranchers
Seasonal	1 – 3 months 1 year	• Expected departure from normal	• Farmers • Other sectors depending on water sources

Table 7: Lead time requirements

The success of Delft-FEWS is also based on its high degree of flexibility when adapting the system to the characteristics of the existing system. The modular and highly configurable nature of the system allows it to be used effectively both in rudimentary and highly complex systems. Nevertheless, care should be taken when designing a forecasting system for a specific area. Some case studies[72] have documented that although flexibility provide considerable advantages, it also adds an increase in complexity. Therefore, the success of the design and implementation of the Delft-FEWS is to find the proper balance between flexibility and complexity.

[72] Werner M.G.F., Schellekens J., Gijsbers P., van Dijk M., van den Akker O. and Heynert K., 2012

6.2. Notification, Decision Making and Warning

DGR as the responsible institution for disaster risk management at regional level receives the meteorological forecast bulletin from SENAMHI through e-mail, although the information is also available on their web page, and also from AASANA through their webpages. SEMENA, via Civil Defence, also sends daily data about their hydrometric stations via e-mail. Finally, DGR occasionally also considers as a reference the forecast bulletins from SNHN available on their webpage; however, because of differences in the methodology of measuring water levels, early warning flood bulletins from SNHN are little used by other institutions but more by navigators, marines. However, some municipalities like Santa Ana del Yacuma use them. UGRs from the municipalities also inform the DGR about the rise or fall of water levels from the stations in their jurisdiction when an event seems imminent. Although DGR receives hydrometeorlogical data from other institutions, this information is used to corroborate the forecast bulletins prepared by this institution and subsequently, its forecast bulletins are sent back to these institutions, more specifically, to SEMENA and SENAMHI. Subsequently, DGR disseminates this information to the UGRs from the municipalities through e-mail or in special cases, phone.

Figure 29: Articles from local newspapers

Nevertheless, when an event is imminent the institutions responsible for the evaluation of monitoring data and forecasting inform DGR and as a result COED is activated. COED monitors the event and starts taking actions as preparation, as well as informing GAD Beni, responsible for taking decisions with COED's support. However, the lead time is usually too short to take useful preventive action or even get fully prepared, instead frequently COED coordinates with national and local institutions including regional Civil Defence and VIDECI and COEMs from municipalities to receive, organize and distribute international and national donations and emergency aid. The communication between these institutions is via e-mail and formal messages. At national level, VIDECI convene other ministries and organizations involved within the field of disaster management in order to articulate national measures in terms of emergency aid. At local level, however, COEMs from municipalities, composed of GAM from municipalities and UGRs, convene a meeting with NGOs and other organizations that work in the area in order to coordinate joint tasks. However, most organizations work

independently rather than coordinating with local institutions.

Before the threat is identified, UGRs from the municipalities receive periodical flood early warning bulletins from the DGR; however, in the case of Santa Ana del Yacuma they have also a WAN communication router and thus, have access to the meteorological and warning information from SENAMHI. In addition, they also check these bulletins from SENAMHI with the meteorological forecasting bulletins from SNHN. Nonetheless, when an event is imminent, a synthesized report of the situation including some pictures of water levels is prepared by the UGRs and is sent to DGR in Trinidad through an official message. Simultaneously, UGRs disseminate warning information to local communities using a special radio frequency. Moreover, the warning information is disseminated to the population using communication media, more specifically they use two Mass Notification Methods for warning dissemination, the conventional Radio and Television. However, and usually, local newspapers do also inform about the event. These broadcasting systems are among the best mass media for distributing general information to an extended area. Updates and emergency instructions can be successfully transmitted by these communication media; however, conventional Radio and Television might not be the most suitable method for first level notification at regional and local level. Moreover, a detailed analysis of the advantages and disadvantages of both Mass Notification Methods is shown in Table 8.

	Radio	Television
Advantages	- Instant communication to recipients - Gives updated detailed information - Available and affordable - Can be used indoors, outdoors, in moving vehicles, etc.	- Instant communication to recipients - Gives updated detailed information - Available - Excellent source of warning and emergency information
Disadvantages	- Have to be tuned in to receive warning - Limited usefulness during some periods of the day - May reach people not affected by the event - Poor over-the-air reception or no local radio service in smaller communities	- Have to be tuned in to receive warning - Limited usefulness during some periods of the day - Limited usefulness outdoors, in moving vehicles, etc. - May reach people not affected by the event - Poor over-the-air reception or no local radio service in smaller communities - Not available during power outages

Table 8: Strengths and weaknesses of the current warning dissemination methods used in Beni

Unfortunately, frequencies of the radio stations did not reach farther that the capital and the communities near the municipality, indicating how isolated these communities are. However, amateur radio is the communication technology used by community peasants to disseminate intercommunity warning information. Finally, door knocking is the main communication method used to warn citizens in a community. Hence, Addressable Notification Methods are the most common communication technologies used at community level.

Figure 30: Communication technology used by UGRs

UGRs from municipalities are not the unique agents for disseminating warning information, due to the lack of interinstitutional coordination both at regional and national level. Citizens receive the information from various sources, formal and informal. At regional level, seven institutions disseminate warning information, these are Civil Defence, DGR, SNHN, SENAMHI, SEARPI and UGRs; however, at national level SENAMHI, SNHN and SEARPI should not take part in this element of the warning chain because warning is not part of their responsibilities. Moreover, several NGOs disseminate warning messages, even though it is not their task either. As a result, during the 2007 and 2008 floods, the population received different warnings from various agents causing confusion and a distortion of the magnitude of the event resulting in dramatic damage at social and economical level. Although emergency plans including warning communication plans were developed after the floods in 2007 and 2008, there was still a lack of coordination during the floods of 2010 and 2011 among the different sources that announced the occurrence of the event. This led to parallelisms when communicating and carrying out preparedness actions. Inefficiency in implementation of emergency plans and warning communication plans results in a reduction of confidence in the information provided.

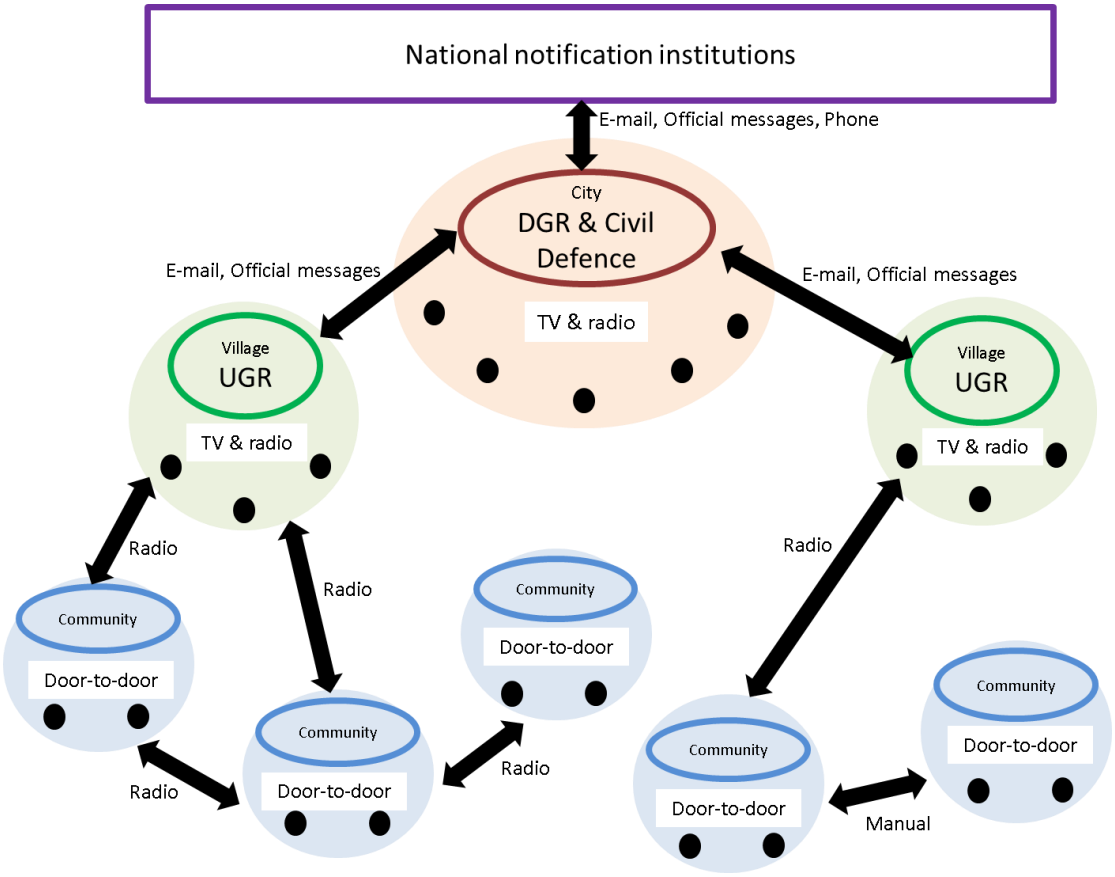

Figure 31: Warning information dissemination network at local level

Analysing the shortcoming in these elements of the warning chain it can be assumed that the lack of coordination between stakeholders has negative consequences to decision makers at national, regional and local level. It has been identified that several warning and flood response measures taken when occurring an event have been carried out in parallel, duplicating efforts. Moreover, several incongruences have been identified in national emergency protocols and regional protocols in terms of institutions involved and their responsibilities. As a result, the update and unification of protocols is crucial.

Figure 32: Group discussion in Trinidad with regional and local institutions

Based on the interviews with citizens, it can be concluded that in the case of the department of Beni, and more specifically, the municipalities of Loreto, Santa Ana del Yacuma and San Ignacio de Moxos, a high percentage of population particularly those who live in communities far from cities and villages, did not receive any official warning message from any official warnings from the responsible institutions as SENAMHI, Civil Defense, UGR or DGR. In those communities the majority (around 90%) detected the threat by observing the river or they received notification from friends. Some communities communicate through the means of amateur radio; thus, their inhabitants that have access to these devices receive warning information from other unofficial sources. Alternatively, television and radio were mentioned by citizens who live in villages and cities as the preferred communication technologies for receiving warning messages. However, most of the inhabitants who live in areas protected from flooding, although they received the warning, did not consider themselves at risk. Leaving these by the way-side, others considered that the warning applies to them however; almost 20% of these did not trust the warning. However, nearly everyone (almost 100%) who considered himself or herself at risk and trusts the warning took preparedness actions in terms of protective actions and in the future they will even take preventive measures because they are completely aware of the high likelihood of future floods.

Instead of what could be expected, citizens knew and understood the meaning of warning. Responders were asked to list and describe existing warning levels and all of those interviewed were able to answer properly. Frequently, however, UGRs from municipalities do not declare every warning level according to the water level and then inform the DGR. Instead and due to several reasons, including the lack of coordination between DGR and UGRs, and the long waiting time before receiving emergency aid, etc., UGRs automatically declare the red warning level. This good performance from citizens regarding warning information is the result of various experiences and risk awareness, as well as, adaptation of warning messages to the specific needs of citizens: warning messages are clearly understandable and although they are in Spanish (instead of the local language) they are adapted to the linguistic characteristics of the zone even to the point of including idioms. As a result, linguistic customization becomes crucial for the implementation of an effective flood Early Warning System.

Warning information should be consistent, accurate, certain, clearly understandable with location specific risk, as well as giving guidance on response activities that can be taken. Although interviewees mentioned that warning frequency was adequate and that today there is a difference between warning levels, they felt that the inaccuracy of warning messages and the ineffective guidance on response mean that citizens, who live in communities without any structural protection against flooding, felt unconfident about warning information. The fact that the warning information dissemination network has important shortcomings at mainly local levels significantly affects citizens' feelings. Alternatively, most of responders who live in areas protected from flooding, for instance, in cities such as Trinidad and in big villages such as San Ignacio de Moxos and Santa Ana del Yacuma, felt confident about warning messages. This variety of opinions shows the

beneficial effects that structural protections might provide and might affect people's feelings.

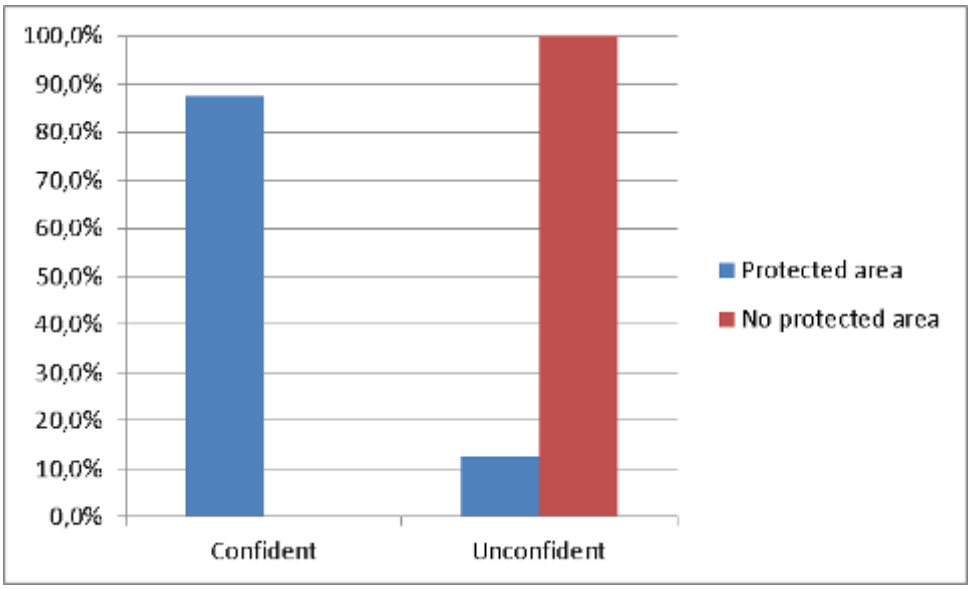

Figure 33: Citizens feelings about warning information

It can be also concluded that citizens living in remote areas and in communities far from villages and cities had little confidence in the messages. This distrust is mainly based on the important gaps in the warning information dissemination network and on the lack of coordination between the individuals and agents who inform about the event. These gaps in the network result in the isolation of these families during large periods of time (2 weeks – 3 months) without any help from outside. As a result, the improvement of the coordination and communication between stakeholders at all levels is crucial and confirms that little attention is paid to the other elements of the warning chain apart from monitoring and forecasting, resulting in dire consequences for the end-users. Warning dissemination and communication should become a priority with regard to the issue of improving the existing Early Warning System in the department of Beni together with monitoring and forecasting.

Distrust of the organizations that protect citizens from natural disasters, including flooding, might be also

influenced by people characteristics. According to the analytical results obtained from interviews, a high percentage of citizens who reside in small villages and communities, belong to an ethnic or racial minority group. Literature research[73] also highlights the influence that educational attainment levels have on people's vulnerability. This statement has been corroborated when interviewing citizens. In a high percentage of communities educational classes for school age children are provided; however, the net enrolment rate is still low, with an average age of 6-7 years. Results from the interviews show that the feeling of vulnerability is accentuated in rural areas and is aggravated by the remoteness of the community.

Vulnerability is also significantly influenced by social ties, including neighbourhood relationships. Socio-economic characteristics, as well as, gender do not nowadays have a substantial influence on citizens' feelings about warning information. However, it does have an influence in flood response actions.

Figure 34: Community called 'San Miguel del Apere' in San Ignacio de Moxos

Finally, the gap between the belief by flood forecasters that a simple but timely and accurate flood forecast has been produced which is an effective EWS in terms of warning dissemination and flood warning and the perceived experience

[73] Mileti D., 1995

of flood-prone communities that no flood warning has been received, leads to the belief that there is an important failure in the early warning information dissemination network in all levels. It has been observed that despite the use of radio, TV, telephones, mobile and conventional phones and emails establish an almost effective communication network, citizens who live in remote areas do not receive any warning information. As a result, the older methods also have their place mostly at local level, which means for example door-to-door. The use of sirens and loudhailers need to be encouraged in order to reach all potential users of the network. Moreover, in order to make citizens aware of the risks of flooding and how to act when an imminent event occurs, as well as, identifying important gaps in the warning information dissemination network, regular practice of emergency message dissemination should be started and continued followed by periodical emergency exercises and simulations.

6.3. Risk awareness, perceptions and citizens reactions

Based on the methodology used to assess flood preparedness behaviour of Dutch citizens carried out by Terpstra[74], the perceptions, emotions and finally, the intentions of citizens are rigorously analysed. Figure 35 reports on willingness to be prepared, as well as, intention to take some prevention and mitigation measures by the population in the department of Beni. It must be noted, that this MSc Thesis makes a distinction between these three terms based on the lead time before the event occurs. Preparation of flood response activities is mainly carried out 2 or 3 days before the event; these activities are considered in this research as protective actions. Main protective actions include ensuring the safety of family members by moving them to other protected areas like

[74] Terpstra T, 2009

'lomas' and 'camellones', building 'chapapas', stockpiling food and shifting household goods to a safe place, for example, onto the house roof. However, prevention and mitigation activities are different if there is a shorter or middle length lead time. The construction of 'lomas' and 'camellones' is the most common activity mainly because almost 100% of citizens feel frightened about leaving their houses and household goods during flooding seasons (which last between 2 weeks till 3 months). This means that around 70% prefer to stay in the flood areas although the risks of economic and social damage are huge. This reaction is based on the high percentage of households that have experienced burglary during flooding seasons, while the owners are living in temporary shelters in areas protected from flooding, for instance, Trinidad, San Ignacio de Moxos and Santa Ana de Yacuma.

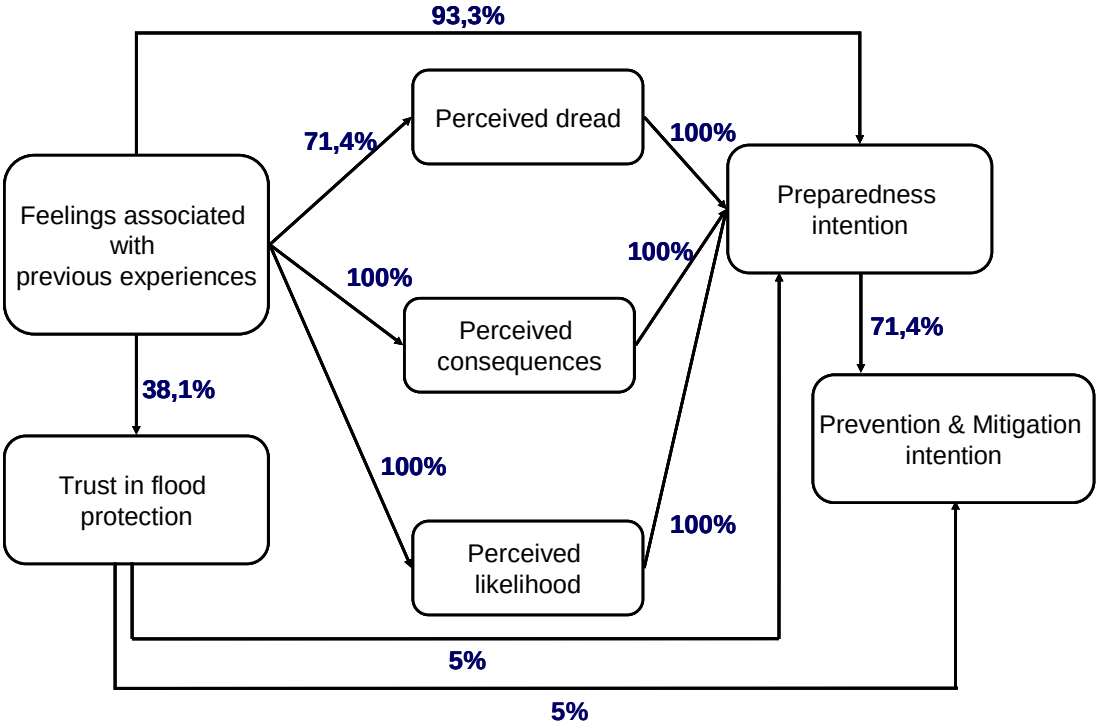

Figure 35: Preparedness behaviour of Beniatan citizens

The likelihood of flooding in the Mamoré river basin is huge. Almost every year some municipalities suffer from this event and suffer the considerable consequences that flooding involves. Therefore, the perceived likelihood of flooding as well as the perceived consequences that this event causes are well known by the population of the Beni region. Specifically, 100% of the population with an age of at least 3 years old know about them. It can be observed that approx. 93% of citizens that have experienced the consequences of flooding, intend to make some preparations such as planning temporary solutions like saving family members by living during flooding seasons in 'lomas', 'camellones', 'chapapas', or other temporary shelters, as well as, saving household goods by putting them on roofs and stocking up with food. In order to have a real view of reality, it is necessary to distinguish between individuals and communities with high and low levels of perceived risk. Thus, population who live in cities, villages and big communities near those villages must be distinguished from people who live in small communities near rivers far from those villages and cities. Those citizens who live in cities and villages frequently feel calm about flooding seasons. This perception is based on the security that protective structural measures bring to citizens. These citizens, who represent 38% of the total population, trust in flood protection and, therefore, they do not consider it relevant to take any preventive or preparedness actions (95%). This 38% also include populations who live in communities near these cities and villages. They trust in flood protection because they perceive the benefits that those measures have, but because they do not live in areas protected from flooding, they take some action in terms of preparation, such as, saving household goods in a safe place and saving family members by living in temporary shelters in roads or other areas protected from flooding like cities and villages. However, these citizens commonly do not intend to make any preventive and mitigation activities because they are used to surviving during flooding seasons with emergency aid from national and

international donations. Thereby, it can be concluded that economic factors like accessibility to financial support and the cost-benefit of taking actions in advance has a huge influence on citizens' responses. However, it must be noted that the importance of these economic factors differ when the location of the communities, villages and cities is taken into consideration.

Finally, people who live in communities far from cities and villages, which represent a great percentage of the population, are well aware of the losses that flooding causes; thus, they plan to take some action in terms of preparedness and also some preventive measures. The difference between these and other citizens lies in the fact that emergency aid and the national and international donations arrive frequently 2 or 3 months after the flooding season has started, which implies that these citizens live in flooded areas that must be completely isolated from other communities and therefore from any outside help. This is one the reasons why it is crucial for these people to make some preparation and take some preventive action. Nevertheless, the remoteness of these communities influences not only emergency aid but also warning dissemination before the event occurs. Interviews with these citizens makes clear that the frequencies of the radio stations did not reach farther than the capital and the communities near the municipality. This weakness reduces local trust of flood protection. More specifically, almost all citizens who live in these communities do not trust in the flood Early Warning System and therefore do not consider that risk management and emergency aid are effective. Therefore, one of the most common measures that these inhabitants have carried out is to leave the community and move to a safer area with relatives.

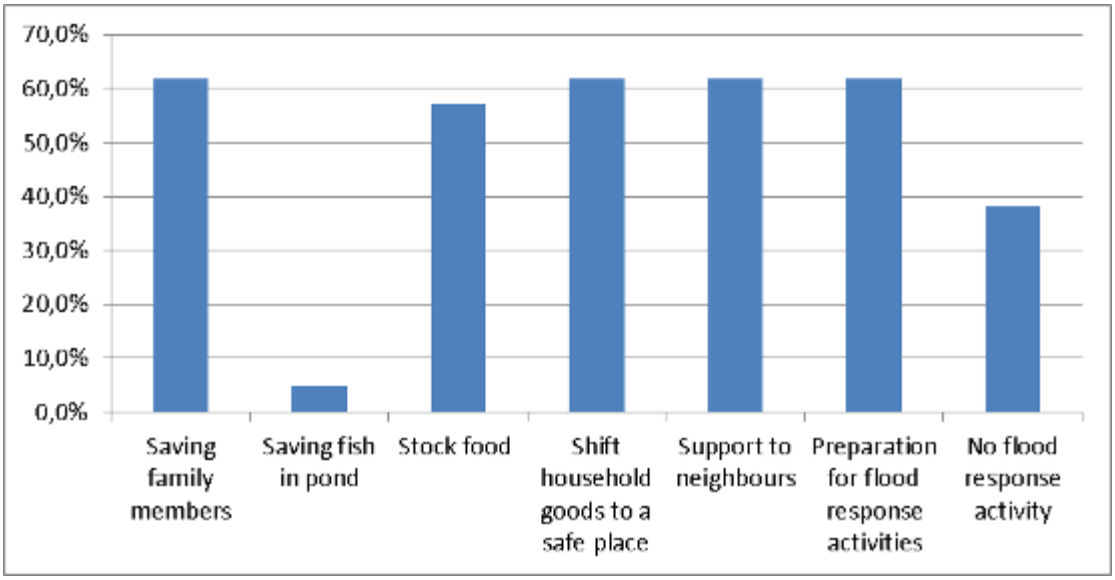

Figure 36: Flood responses carried out by citizens

It can be concluded that although these citizens prepare flood responses, whether by stocking food for livestock, saving agricultural crops or building temporary 'chapapas' to save family members and livestock using wood as raw material; because no warnings are broadcast in these areas, populations do not make advance preparations or take advance preventative actions sufficient lead time. Instead, they start to take action when the occurrence of the event is imminent. As a result, community members frequently do not have enough time to take effective preparedness actions.

The results show that flood response is considerably influenced by people characteristics, with particular reference to socio-economic groups and work and resources. As the primary economic activity and land use practice in Beni is ranching, particularly extensive livestock farming, and the secondary economic activity is agriculture, the specific flood response actions of farmers and cattle ranchers are analyzed.

Cattle ranchers usually have regular periodic communication through radio with FEGABENI in order to know the status of the river basins, for instance, the Mamoré river. The parameters in which they are more interested are water level and the

flooding areas. According to this information, ranchers who have already had some previous experiences (almost 100%) with flooding always take some specific preparation activities, for instance, saving livestock and stocking food for them or selling cattle to slaughterhouses. Flood responses differ depending on the number of heads of cattle that the farmer owns. Big ranchers have periodic communication with FEGABENI in order to be conscious of lead times before an event happens; thus ensuring that they have sufficient lead times to sell cattle or save cattle by moving them to high areas. Otherwise, their economic losses can be huge. Small ranchers will make some other preparations, for instance, building 'chapapas' or moving cattle to high areas called 'lomas' and ' camellones' near the community.

Figure 37: Lomas and Camellones in santa Cruz de Yacuma

Farmers who work in agriculture growing crops, frequently (almost 70%) do not take any preparation actions for flood response activities due to two main reasons: one, the minimal lead time required by farmers is 3-4 months and two, they are used to applying for national and international donations as emergency aid. Therefore, the number of farmers continues to decline further although some specific actions are carried out by the regional government and NGOs.

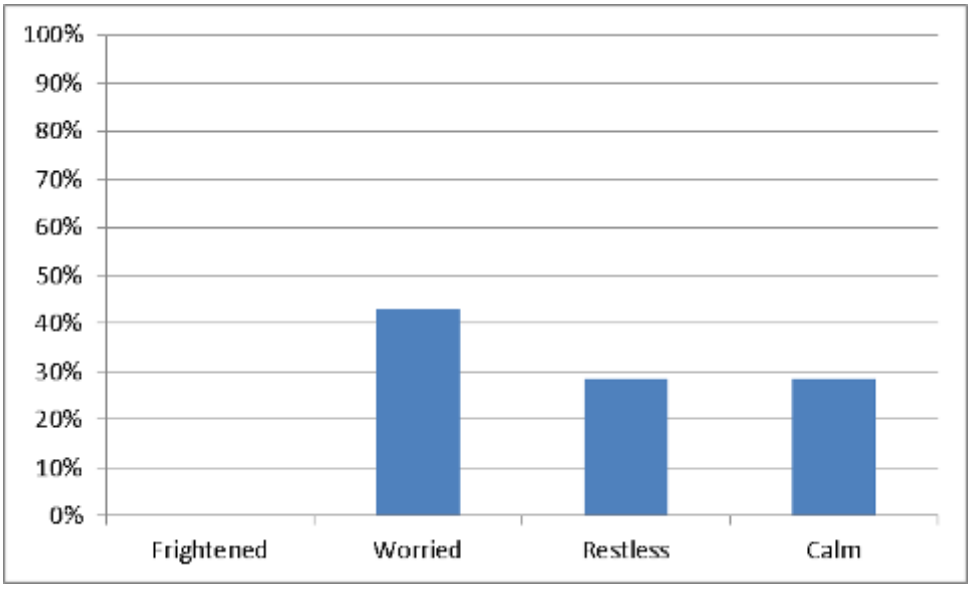

Figure 38: Citizens feelings about the risk of flooding

Focusing on citizens' feelings and emotions about the risk of flooding, most citizens that live in potential flooding areas without any structural protective measures are used to flooding seasons, understand risk awareness and are fully aware of the specific consequences of flood. Figure 39 shows citizens feelings about the risk of flooding in the areas where they live. It must be noted that all interviewees had already experienced flooding, as the likelihood of flooding in the department of Beni is very high. Almost every year there are some communities that are completely flooded. The graph shows that 43% of persons interviewed feel worried when they think about the risk of flooding in their areas and almost 30% feel restless. However, surprisingly, nobody feels frightened about it and around 30% feel calm. This range of feelings might be a consequence of both familiarity with the likelihood of flooding event in the area as well as various preventative measures that are being taken by the regional government and some NGOs to reduce the economic and social impact of these events. It should be mentioned, however, that almost all the citizens that feel calm live in higher and/or protected areas such as Trinidad. However, there are some men, who are over 55 years old, that are extremely used to these events, so they do

not feel worried or even restless when they think about the risk of flooding. It can also be seen that feelings do not vary considerably with age or gender when the person has already had some experience with flooding seasons. As a result, environmental cues, which include the familiarity of the hazard in the locality, have a strong influence on citizens' vulnerability, on their preparedness and intentions to take preventative measures and of their flood responses.

The results from the interviews also show that social setting and social ties have an impact on citizens' responses. Although every family first takes care of their goods and family members, communal activities which help everybody will also be undertaken, for instance, the construction of 'chapapas', saving food, bringing livestock to higher areas like 'lomas' and 'camellones', etc.

Figure 39: Interviewing citizens

In addition, another factor which affects response is socio-economic status in particular when moving population from a community to the 'lomas' and 'camellones' near the community. Such is the case of 'Camiaco', when they consider that an event is likely to occur, action is taken. One of these measures is to move family members, as well as, livestock and household goods to higher areas. As two 'lomas' are located near the community, people and their household goods and

livestock are distributed among both 'lomas'. This distribution is based on people's socio-economic status: in one loma the Corregidor and his family, nurses and teachers and other members of the community with a higher social status would be established, while small cattle ranchers, small farmers and other members of the community with a lower socio-economic status would live temporarily in the other 'loma'.

In terms of response the main activities that should be carried out when designing a EWS based on a multi-level stakeholder involved approach are listed below:

- Identification of target populations, especially the vulnerable and disadvantaged, and interaction with them to determine needs and capacities.
- Involvement of communities by conducting town meetings when inhabitants can explore and map their risk and plan their responses.
- Periodical meetings with local, regional and national institutions in order to join efforts in terms of preparedness and preventative actions
- The fostering of the development of monitoring and warning systems for local risks by communities within the locality.
- Generation of public information tailored to target groups and make innovative use of the media and education systems.
- Development of formal mechanisms for public representatives to monitor and oversee warning system design.
- Further research into factors that enhance or impede human understanding of and response to warnings.
- Provision of exercises and simulations to enable people to experience and practice warning interpretation and responses.

Finally, based on these observations and with the purpose of increasing the likelihood of the successful design and implementation of a flood warning system, this MSc Thesis recommends that all relevant stakeholders should be involved in the development of the system to ensure that the issues of greatest concern are identified and addressed. It is important that these stakeholders include persons that previously have been affected by natural disasters.

Apart from this observation, it must also be stressed that the sustainability of risk disaster management has a large dependency on the development of a local management team, which implies the need of solid institutional structures by focusing efforts on the interinstitutional coordination, to stimulate and coordinate on a permanent and sustained basis not only in the short term but also in the middle and long term.

6.4. Early Warning Systems Comparative analysis

The development of a new flood Early Warning System in the department of Beni in Bolivia is based on the identification of weak links in the warning chain of the existing Early Warning Systems throughout Bolivia, more specifically, in Cochabamba, Santa Cruz de la Sierra and Beni. Therefore, Table 9 shows the strengths and weaknesses of the elements of these three warning chains.

Early Warning System	MONITORING	FORECASTING	NOTIFICATION	DECISION MAKING	WARNING	RESPONSE
Santa Cruz						
Beni						
Cochabamba						

Table 9: Strengths and weaknesses of the main flood EWS in Bolivia

7. Conclusions and recommendations

The importance of an effective Early Warning System for disasters cannot be underestimated. These warning systems are frequently considered as the most effective non-structural measure in the short term to reduce the dramatic damage that floods and other events produce. At individual level, the implementation of an Early Warning System can mean the difference between life and death. At local level it can mean the difference between being able to generate stable social structures and wealth enough to support local families and businesses with livelihoods. At national level, the success of disaster management systems can seriously affect GBP and the ability of a country to develop and grow at global level, the success of an Early Warning System can impact on international emergency aid, which can then be diverted to other needy areas of the world.

While carrying out research for the Beni project, it became apparent that the number of factors involved in the successful design, implementation and sustainability of a flood Early Warning System are diverse and wide ranging. Unfortunately, a high number of previous projects regarding disaster risk management including warning systems in the department of Beni and in Bolivia have not assured their success in terms of the effectiveness and sustainability in the short and long term. This failure is mainly based on the lack of understanding about the local situation.

The existing flood Early Warning System in the department of Beni in Bolivia works to a certain extent but there are specific parts that could be improved. Suggestions for improvements have been obtained from interviews and group discussions with stakeholders and from a literature review of other warning systems implemented in other departments of Bolivia and worldwide. These suggestions have been explored

with regard to practicality, cost effectiveness and sustainability. Recommendations can be summarized as follows:

Design of the Early Warning System:

Although recent efforts have been made to combine the human factor of the disaster risk management and flood Early Warning Systems, the involvement of the stakeholders in the system's development is still one of the main challenges that face flood Early Warning Systems. The warning system needs to be designed and developed according to the needs of the stakeholders involved and considering their interests. National governments, the current early warning organizations, regional and local governments, local organizations, NGOs, businesses and inhabitants should be considered as stakeholders.

Suggested Improvements:

- More could be done to involve all included stakeholders through national and local group discussions to ascertain the needs of groups and individuals and those of particular need. These meetings need to be carried out before and after an event to ensure that experience and design of system is based on real and actual facts.
- Further cooperation between local, regional and national organizations such as SENAMHI and SEARPI or UGRs from municipalities and DGR should be increased through periodical meetings. The willingness to join efforts to reduce damage caused by floods should be prioritized by putting differences aside. The sharing of technologies and information might be mechanism to seek common ground.
- The creation of a unique organization responsible for the disaster risk management in the Mamoré river basin is necessary in the long term in order to reduce the existing dispersion of stakeholders involved with similar roles. Also the strong competiveness would be drastically reduced.

- Local governments need to take seriously disaster risk management including Early Warning Systems as a priority: ensuring sufficient funding for O&M, equipment, logistics, emergency aid, etc., reducing instability of staff, reducing paperwork in order to accelerate action time, strengthening local capabilities, etc. In order to improve local capabilities, local governments might offer training subsidies for companies or individuals to become a community watch and warning team to encourage the development of preparation workers. Local businesses might be required to have a management training programme or to support educational programmes in the workplace.
- National governments might wish to encourage groups of global disaster consultants to hold seminars and conferences on the topic for the global sharing of information and expertise. Local experts need also be invited in order to ensure successful knowledge sharing.
- National governments and organizations together with international organizations and consultants need to be aware of the local situation including local interest and needs. Therefore, periodical missions in the field are crucial.

Monitoring and Forecasting

The current Early Warning Systems focuses mainly on the hazard itself, therefore, monitoring and forecasting are considered the most relevant activities within the warning chain. Unlike other warning systems, the flood Early Warning System in Beni puts emphasis on the needs and interests of the stakeholders involved and therefore the improvement of the monitoring network and forecasting information is adapted to users. Field research shows that a variety of information and lead times at which forecasts are required. While flood response agencies , for instance, SEMENA,SEARPI, SENAMHI, COED Beni, COEM from municipalities and NGOs, and cattle ranchers are interested in water levels, discharges and potential flooded areas with a lead time of two-three weeks maximum, farmers need medium and

extended range forecasts with a lead time of three or four months. Finally, farmers and other agencies are also interested in seasonal forecasts.

Suggested Improvements:

- The monitoring network in Beni needs to be extended installing hydrometeorological stations in strategic points on the basis of the existing local experience, hydrological modelling and an accurate diagnosis about the existing network including the status of the stations.
- Although the existing forecasting system based on the accumulated experience and empirics has achieved good results in terms of damage reduction, the automation of the system is necessary because more extensive lead time is demanded by the stakeholders.
- More could be done to customize forecasts by adapting the forecasting information to stakeholders needs in terms of specific parameters like lead time, water levels, etc., strategic information points, adjusting forecasting information to users' language, amongst others.

Warning Dissemination

The method of warning dissemination needs to be flexible, comprehensive, timely and impervious to power outages or other disaster hazards. The existing warning information dissemination network theoretically considers all users; however, research in the field has shown that some areas do not receive warning information.

Suggested Improvements:

- The important failures in the warning information dissemination network causes that other stakeholders not directly involved within the field of disaster risk management play a crucial role. As a result, reaching the right target recipients is an issue if national and local communication media are involved. Emphasis on the sustainability of the communication network in terms of

local capabilities and logistic and communication equipment is indispensable.

- The flexibility of other existing systems, such as the Flood Early Warning Systems in Bangladesh and in Mozambique, need to be rigorously analysed and adopted by Bolivian institutions. However, the use of radio, TV, telephones, mobile phones, conventional phones and emails, also shows the willingness for individuals and groups to be flexible. However, other traditional warning systems such as door knocking also have their place mostly at local level. The use of sirens and loudhailers need to be encouraged in order to reach all potential users of the network.
- National and local governments and institutions like Civil Defence need to monitor all emergency teams to ensure that no-one is missed in an emergency and also that emergency aid arrive timely to all communities affected.
- The timeliness of warning messages needs to be monitored. In the Netherlands, regular practice of flood sirens takes place every first Monday of the month at 12 noon. Annual emergency messages on the new national mobile phone alert system are sent to check that everybody can be quickly reached should it be needed. Everybody knows what to do if these go off at other times:" We are to return home and switch the television on for more information". This project therefore suggests regular practice of emergency message dissemination be started and continued.

The Early Warning Message

The factors of most importance that influence the different types of response of the inhabitants and the preparedness planning by organizations are that they reach the right target recipients and that they are accurate, reliable, believable and timely. It must be noted that many of the factors are

already being addressed in part in the current Early Warning System. However, the success of warning messages varies according to the visibility of floods by the population.

Suggested improvements:

- The believability of messages is largely based on the agent, who disseminates the warning. The lack of coordination between these agents affects the trust in warning messages. If national and local disaster risk management institutions – as trained by the national and local governments as suggested in the design improvements – give the message, it might be seen as more believable than otherwise.
- The accuracy of messages has not really been doubted by those inhabitants living in areas protected from floods; however, populations living in remote areas near the river check the accuracy of the warning message – if they receive it- mainly by personal observation. The aggregation of all monitoring information in a single platform allows monitoring the entire river basin reducing the gaps of information which cause the inaccuracy of warning messages.
- Again, the timeliness of messages is vital to minimise damage of any sort and to activate preventative activities. This needs to be monitored and managed in a standardized and structured way. Moreover, it was evident that the messages were not always clear and that some people felt that they had not been received at all. The standard unification of nationwide warning levels code, its associated risk and expected preventative activities for each level of event is necessary to be carried out in order to make everything clear for all stakeholders. A nationwide communication and education programme would be required to teach everybody the basics.

Response Activities

Results from the MSc research have shown that citizens take action depending on their awareness of risk which includes prior experience and socio-demographic characteristics. While people living in remote communities far from villages and cities are more aware of taking action in terms of preparedness, inhabitants living in areas protected from floods do not consider as relevant to take action because they do not perceive the risk. Results show that a high number of people prefer to stay in the flood areas although the risks of economic and social damage are huge. This reaction is based on the high percentage of households that have experienced burglary during flooding seasons, while the owners are living in temporary shelters in areas protected from flooding, for instance, Trinidad, San Ignacio de Moxos and Santa Ana de Yacuma. It can be concluded that the feeling of vulnerability is accentuated in rural areas and is aggravated by the remoteness of the community. Other factors such as social setting and social ties and the socio-economic status have also an impact on vulnerability and flood responses. Although every family first takes care of their family members and household goods, communal activities are also undertaken, for instance, bringing livestock to higher areas.

Suggested Improvements:

- All the warnings need to be linked to a set of learned actions that will help people prevent or recover from damage. Creation of publications, annual events of public memory and learning are needed in order to enhance information availability at regional, national and international level.
- Regular meetings with national and local organizations involved in the emergency preparation and response should be encouraged in order to coordinate response activities and avoid duplications and parallel efforts. Also communities need to be involved in exploring and mapping their risk and planning their responses.

- Information bulletins about the likelihood of risk, preventative actions, etc. need to be distributed to the population in order to increase their risk awareness and intentions to take action when an event occurs.
- More local volunteer groups and organizations should be recruited to learn what to stock in the way of emergency items, how to make water or food safe after an event, how to cook with minimal equipment, where to move the disabled or elderly, etc. Also workshops addressed to inhabitants, who are willing to attend a training course, need to be carried out periodically.
- Provision of regular exercises and simulations to enable people to experience and practice warning response needs to be encouraged. This not only influences how people respond when flood occurring; it also has an influence on the inhabitants' knowledge of risk.

Finally, I would like to highlight that despite the few case studies that currently combine social science with engineering approaches to Early Warning Systems, which are mainly set in urban areas in industrialized countries, and the lack of available information which is even more striking in the context of rural areas in developing countries, the success of this warning system designed and implemented in the department of Beni in Bolivia has been achieved because of this combination of both aspects: Early Warning Systems and the human factor. Much of the research therefore for this MSc Thesis is original and has been carried out in the field. It is the hope of the author that it will make a significant contribution to the availability of information for any future research into the development and enhancement of disaster management and associated flood Early Warning Systems.

Annex 1

Variables	Description	Element from warning chain	Study area	Questions	Basic forms	Answers
Gender	-Gender influences people perceptions of flood risk -Influence people vulnerability	Emergency response Warnings communication	People characteristics	*-Qué edad tiene?*	Closed question	Man or woman
Age	-Age influences people perceptions of flood risk -Influence vulnerability. -Access to and willingness to use communication technologies -Change agents: young people	Emergency response Warnings communication	People characteristics Barriers of communication Risk knowledge	*-Cuántos años tiene?*	Closed question	-16-34 years -35-45 years -45-55 years +55 years (elderly)
Disability	-Indication of access to use of communication technologies -Influence on	Emergency response Warnings communication Warning	People characteristics Special needs	*-Tiene alguna discapacidad?*	Open question with field coding	-Visual impairments - Blind -Hearing impairments -

	people vulnerability	information				Deaf -Physically disabled
				-Qué grado de discapacidad?		-Disease -Deficiency -Disability -Handicap
Ethnic minority	-Indication of access to use of communication technologies -Influence on people vulnerability.	Emergency response Warnings communication Warning information	People characteristics Special needs Risk knowledge	*-Se considera discriminado por su etnia y/o diferencia cultural?* *-De qué manera?*	Open question without field coding	
Language	-Indicates access and use of communication technologies -Influence on people vulnerability	Emergency response Warning information	People characteristics Special needs Barriers of communication	*-Cuál es su lengua materna?* *-Tiene problemas para entender el castellano?* *-Es necesario adecuar el mensaje a su lengua?*	Open question without field coding	
Educational attainment level	-Indicates access and use of communication -Influence on people vulnerability -Assessment of enrolment rate (years) and level of education	Warning communication Warning information Emergency response	People characteristics Barriers of communication	*-Ha ido a la escuela? Y a la universidad?* *-Cuántos años ha estudiado?*	Open question without field coding	

Social ties	-Indication of access to communication -Influence on people vulnerability -Assessment of the social level	Warning information Warning communication	People characteristics Barriers of communication	*-Cuántos son en la familia?* *-Cuántos viven en esta casa?* *- La familia está unida?* *-Cómo es su relación con los vecinos?* *-Participa en las actividades comunitarias?*	Open question without field coding	
Socio economic group	-Indicates access to communication -Influence on people vulnerability -Job description -Identification of their status within the community	Warning information Warning communication	People characteristics Barriers of communication	*-Desarrolla algún papel importante dentro de la comunidad?* *-Qué nivel socio-económico ocupa dentro de la comunicad?*	Open question without field coding	-Community leader -Change agents
Work and Resources	-Indicates access and willingness to adopt and use communication -Influence on people	Warning information Warning communication Emergency response	People characteristics Risk knowledge	*-Qué propiedades tiene?* *-Dónde están?* *-Dónde trabaja/está normalmente?*	Open question with field coding	-Trabaja en casa -Está donde sus pertenencias (puesto fijo) -Está donde sus pertenencias (puesto variable

	vulnerability -Identification of properties and work location					e.g. cattle)
Previous experiences	-Indicates willingness to adopt and use communication -Influence on people vulnerability -Identification of similar experiences from past events	Warning information Warning communication Emergency response	People characteristics Risk knowledge	*-Ha tenido alguna experiencia anterior con inundaciones?* *-Cuántas?* *-Dónde estaba cuando se enteró?*	Closed question	Yes / No Years
			Perceived dread	*-Me podría indicar cómo se siente en este momento si piensa en el riesgo de inundaciones en esta región?*	Closed question	-Aterrodizado -Preocupado -Inquieto -Tranquilo
			Perceived flood consequences	*-Cree que las consecuencias de las inundaciones pueden afectar a su personalidad?* *-Cree que puede tener consecuencias fatales?*		

Environmental cues	-Flood risk perception -Influence on people's vulnerability -Visibility of hazard in the locality	Emergency response	People characteristics Risk knowledge Perceived flood likelihood	*-Cree que frecuentemente se producirán inundaciones?* *-Cree que si viviera en otro lugar las inundaciones no ocurrirían?*	Open question without field coding	
Lead time	-Identification of the response time before the event	Monitoring and warning service	Need for information	*-Antes de que ocurriera la inundación le avisaron?* *-Recuerda cuánto tiempo antes?*	Closed question	Hours/Days
Warning levels	-Identification of the different warning levels need	Warning communication	Warning levels	*-Le avisaron justo antes que pasara la inundación o bastante tiempo antes?* *-Hubo alerta verde, amarilla, naranja y roja?*	Open question without field coding	
Experience with technology	-Indication of willingness to adopt and use communication -Identification of current communication technologies	Warning communication	Flood warning technologies	*-Cómo le avisaron?* *-Usan varios métodos?* *-Cambian cada año de métodos?* *-Cuál de ellos prefiere?*	Open question with field coding	Mass notification methods: -Loudhailers - Sirens - TV - Radio

						Addressable Notification Methods: - voice - door knocking
Knowledge about technology	-Indicates willingness to adopt and use communication -Identification of knowledge about existing technologies	Warning communication	People characteristics	*-Cómo funciona(n) esta(s) tecnologías?*	Open question without field coding	
Manner in which technology is introduced	-Indicates willingness to adopt and use communication	Warning communication	People characteristics	*-Quién les enseño cómo funcionan?* *-Cómo y cuándo les enseño?*	Open question without field cod	
Reputation of technology	-Indicates willingness to adopt and use communication -Identification of technology effectiveness -Assessment if the first step of emergency	Warning communication Emergency response: NOTICING	People characteristics Flood warning technologies	*-Son efectivas estas tecnologías?* *-Que tecnologías son mas efectivas las individuales, comunitarias o las de trasmisión?* *-La información llega a todo el mundo?* *-Funcionan o se*	Open question without field coding	

	response is followed (NOTICING)			*estropean normalmente?* *-La gente sabe cómo hacerlas funcionar?*		
Perceived benefits and disbenefits	-Indicates willingness to adopt and use communication -Identification of perceptions	Warning communication	People characteristics Flood warning technologies	*-Cree que es importante el uso de estas tecnologías?* *-Que problemas ve en estas tecnologías?*	Open question without field coding	
Warning source	-Identification of communication agencies: Official, Unofficial and/or no warning	Warning communication Emergency reponse: OFFICIAL WARNING UNOFFICIAL WARNING NO WARNING	People characteristics Barrier of communication	*-Quién le informó?* *-A quién hizo caso?*	Open question with field coding	-Governance (National, regional, local) -NGOs -Citizens -Comm. media
Reputation of agency	-Indicates willingness to adopt and use communication - Credibility and reliability of agencies	Warning communication Emergency response	People characteristics	*-Son creíbles?* *- Son fiables o se equivocan mucho?* *-Confía en ellos?*	Open question without field coding	

Structures of governance	-Identification of the local, regional and national structures of governance -Identification of their role within EWS	Warning communication Emergency response	Barrier of communication	*-Cree que el gobierno local, regional y nacional es efectivo cuando hay una inundación?* *-Qué acciones llevan a cabo?* *-Tienen un papel importante o son otras organizaciones las que hacen el trabajo (ONGs)*	Open question without field coding	
Structures of other agencies	-Identification of the local, regional and national structures of agencies -Identification of their role within EWS	Warning communication Emergency response	Barriers of communication	*-Cree que tal y como está organizado ahora, cuando viene una inundación son efectivos?* *- Quién se encarga de qué?*	Open question without field coding	
Annual costs	-Indicates willingness to adopt and use communication -Identification of the annual costs of communication technologies	Warning communication	People characteristics	*-Tiene que pagar algo por estos métodos de comunicación?* *-A quién le paga?* *-Cuánto paga?*	Open question without field coding	

Warning frequency	-Identification of warning frequency - There is a difference between warning levels?	Warning information	Warning efficiency	*-Cuándo falta poco para que ocurra la inundación se emiten comunicados y/o alarmas para avisar a la población?* *-Según el tipo de alarma la frecuencia varía?*	Open question without field coding	
Risk location information	-Identification if other no flood-prone communities also receive warnings	Warning information	Warning efficiency	*-Sabe si se avisa también a otras comunidades, que no están en situación de riesgo, sobre la inundación?* *-Cree que sería importante avisar a otras comunidades?*	Open question without field coding	e.g. Preparedness for emergency aid
Warning clarity	-Identification if the message is well understood	Warning information Emergency response: UNDERSTANDING	Warning efficiency People psychological characteristics	*-Entendió todos mensajes de alarma?* *-El mensaje estaba escrito con palabras claras y con un lenguaje simple?* *-Entendió el mensaje?* *-Entendió que tenía que hacer?*	Open question without field coding	

Sufficient information	-Analysis if citizens consider themselves as target groups after hearing the warning message	Warning information Emergency response: CONSIDERING TARGET	Warning efficiency	*-El mensaje contenía suficiente información como para que usted supiese que el mensaje iba dirigido a usted?* *-Qué contenía el mensaje?*	Open question with field coding	- physical characteristics -character of risk
Message accuracy	-Analysis if citizens trust the message information or they are sceptical about it?	Warning information Emergency response: TRUSTING	Warning efficiency	*-El mensaje era preciso?* *-Le dio la sensación de que decía toda la verdad?* *-Se informaba a tiempo real o la información de los mensajes iba con retraso respecto a los acontecimientos?* *-Tenía datos completos?*	Open question without field coding	
Certainty of message	-Analysis if citizens trust the message information or	Warning information Emergency response:	Warning efficiency	*-Le dio la sensación que estaban seguros de la información que*	Open question without field	

	they are sceptical about it?	TRUSTING		*daban?*	coding	
Warning message consistency	-Is there consistency with all warning messages?	Warning information Emergency response: TRUSTING	Warning efficiency	*-Todas la información que daban las agencias coincidía?* *-Se iba informando cuando surgían cambios?*	Open question without field coding	
Confirm the threat	-Identification if people seek confirmation from other sources before acting	Warning information Emergency response: CONFIRMING	Warning efficiency	*-Antes de empezar a actuar buscó la confirmación de otras fuentes?* *- Cuáles?*	Open question without field coding	
Guidance	-Identification if the message was effective in terms of taking action	Warning information Emergency response: ACTING	Warning efficiency	*-El mensaje decía que se tenía que hacer?* *-Dónde ir?* *-Se informaba de cuánto tiempo se disponía antes de la inundación?* *-Siguió las indicaciones?* *-Dependiendo del tipo de alarma debe actuar diferente?*	Open question with field coding	-Protective actions to take -Lead time -Impact location

Psychological characteristics	-Identification of people's response according to their capabilities	Warning information Emergency response: ACTING	People characteristics	*- Se quedó bloquead@ o rápidamente reaccionó? -Fue a buscar a otra gente para que la ayudaran o lo hizo sol@?*	Open question without field coding	
Response	-Identification of people's response	Emergency response: ACTING	Taking action	*-Tuvieron que ser evacuados? -Dónde fueron? -Cómo fueron? -Quién les llevó? -Fueron a casa de parientes? -Se habían habilitado refugios de emergencias? - Que establecimientos se usaron? -Tenían las necesidades básicas como agua, comida, etc?*	Open question with field coding	-Emergency shelter -Temporary shelter
Estimated loses	-Identification of economic damage by estimating the	Emergency response	Costs Perceived flood consequences	*-Las inundaciones le causaron daños a nivel económico? -Qué perdió o se*	Open question without field	

	cost of losses			*malmetió?* *-Le dio tiempo a salvaguardar sus pertenencias en un sitio seguro antes de la inundación?* *-Dónde?* *-Cree que es importante salvaguardar sus pertenencias?* *-Tiene algún seguro que le cubra los daños por inundación?* *-Cree que mejoraría su situación si tuviera un seguro?* *-Recibió alguna ayuda?* *-Cuánto tiempo recibió la ayuda?* *-Que organización le ayudó?*	coding	
Personal damage	-Identification of personal damage including physical and psychological damage	Warning communication Emergency response	Risk knowledge	*-La inundación le causó algún daño físico o psicológico?* *- Perdió a algún familiar?* *- Ha habido*	Open question without field coding	

				cambios en la familia? *-Ha recibido ayuda médica?* *-Quién se la proporcionó?*		
Behavioural consequences	-Identification of peoples perceptions after a disaster	Emergency response	Risk knowledge	*-Tiene miedo de que venga otra inundación?* *-Cree que con un nuevo sistema de alerta la situación mejorará?* *-Tiene intención de prepararse?* *-sabe cómo se preparan otras comunidades?* *-Tiene intención de participar activamente en el desarrollo del nuevo sistema?*	Open question without field coding	
Preparedness	-Identification of preparedness actions	Emergency response	Risk knowledge	*-Cuándo pasa una inundación normalmente se toman acciones antes?* *-Qué acciones?* *-Quién las organiza?*	Open question without field coding	-Acciones de capacitación -Acciones de preparación

				-Sirven de algo? *-La gente participa?*		
			Flood preparedness intentions	*Está interesado en disponer de información sobre medidas de preparación ante inundaciones?* *-Hasta ahora ha intentado buscar información?* *-Está dispuesto a tomar medidas de prevención y de preparación?*	Open question without field coding	-Acciones de capacitación -Acciones de preparación

Annex 2

Interviews with inhabitants

People characteristics:

1) Qué sexo ☐ Mujer ☐ Hombre tiene?

2) Qué edad tiene? ☐ 16-34 ☐ 35-45 ☐ 45-55 ☐ +55

3) Tiene alguna discapacidad? ☐ Si ☐ No

- ☐ Discapacidad visual - Ceguera
- ☐ Discapacidad auditiva - Sordera
- ☐ Discapacidad física
- ☐ Discapacidad psíquica
- ☐ Otros: ……

4) Qué grado de discapacidad?

- ☐ Enfermedad
- ☐ Deficiencia
- ☐ Discapacidad
- ☐ Minusvalía

5) Se considera discriminado por su etnia y/o diferencia cultural? ☐ Si ☐ No

6) De qué manera? .....

7) Cuál es su lengua materna?

..... ☐ Si ☐ No

8) Tiene problemas para entender el castellano?

9) Ha ido a la ☐ Si ☐ No escuela?

10) Ha ido a la ☐ Si ☐ No universidad?

11) Cuántos años ha estudiado?.....

12) Cuántos son en la familia? .....

13) Cuántos viven en casa?.....

14) La familia está unida? .....

15) Cómo es su relación con los vecinos?

.....

16) Participa en las actividades

comunitarias?.....

17) Desarrolla un papel importante dentro de la

comunidad?.....

18) Qué nivel socio-económico ocupa dentro de la

comunidad?.....

19) Trabaja?.....

20) Dónde trabaja o se encuentra

normalmente?.....

21) Tiene algunas propiedades?

Cuáles?.....

22) Dónde están ubicadas las

propiedades?.....

Flood preparedness: Risk knowledge, Perceptions and Experiences:

23) Ha tenido alguna experiencia anterior con inundaciones? ☐ Si ☐ No

24) Cuántas?.....

25) Dónde estaba cuando se enteró (generalmente, en la última inundación)?.....

26) Cree que frecuentemente se producirán inundaciones en esta región?.....

27) Cree que si viviera en otro lugar las inundaciones no ocurrirían? ☐ Si ☐ No

28) En caso afirmativo, porqué permanece en esta región y no se desplaza?.....

Warning – Lead time:

29) Antes de que ocurriera la inundación le avisaron? ☐ Si ☐ No

30) Le avisaron justo antes que pasara la inundación o bastante tiempo antes?.....

31) Recuerda cuánto tiempo antes?..... ☐ Si ☐ No

32) Sabe si existen diferentes tipos de alertas?

33) Qué tipos de alertas existen?.....

34) En la última experiencia que tuvo recuerda si se declararon las alertas amarilla, naranja y roja?.....

Warning – Warning dissemination methods:

35) Cómo le avisaron?.....

36) Usaron varios métodos de transmisión de la alerta?.....

37) Recuerda si en las últimas inundaciones siempre se usaron los mismos métodos que en ocasiones anteriores o éstos cambian cada año?.....

38) Cuál de ellos prefiere?

- ☐ Voz - Portavoz
- ☐ Llamar a la puerta
- ☐ Altavoces
- ☐ Sirenas
- ☐ TV
- ☐ Radio
- ☐ Otros: ……

39) Usted sabe cómo funciona(n) esta(s) tecnologías?.....

40) En general la gente sabe cómo hacerlas funcionar?.....

41) Quién les enseñó cómo funcionaban?.....

42) Cómo y cuándo se les enseñó?.....

43) Son efectivas estas tecnologías? ☐ Si ☐ No

44) Cuál de ellas es la más efectiva, la que informa individualmente o colectivamente? .....

45) La información llega a todos?.....

46) Funcionan o están estropeados con frecuencia?.....

47) Cree que es importante el uso de estas tecnologías para poder alertar a la población?.....

48) Qué problemas ve en estas tecnologías?.....

49) Usted tiene que pagar algo por ☐ Si ☐ No

estos métodos de comunicación de la alerta?

50) En caso afirmativo, a quién le paga?.....

51) En caso afirmativo, cuánto paga?.....

Warning – Agents:

52) En la última experiencia que recuerda, quién le informó del evento?.....

53) Si varias instituciones informaron, a cuál de ellas le hizo caso?.....

54) Las instituciones que alertan son creíbles o desconfía de ellos?.....

55) Cree que el gobierno local, regional y nacional es efectivo cuando hay una inundación?.....

56) Qué acciones llevan a cabo los gobiernos?.....

57) Los gobiernos e instituciones públicas tienen un papel importante o son otras organizaciones las que hacen el trabajo (ONGs)?

58) Quién se encarga de qué acción?.....

59) Considera que tal y como está organizado ahora el sistema, cuando surge una inundación las organizaciones son efectivas?.....

Warning – Warning message:

60) Cuánto falta poco para que ocurra una inundación se emiten comunicados y/o alarmas para avisar a la población?

61) Según el tipo de alarma la frecuencia de los mensajes de alerta varia?.....

62) Cada cuándo se emiten los comunicados?.....

63) Sabe si se avisa también a otras comunidades que no están en situación de riesgo sobre la inundación?.....

64) Cree que sería importante avisar a otras comunidades?.....

65) Entendió los mensajes de transmisión de la alerta?.....

66) Considera necesario adecuar el mensaje de alerta a su lengua? ☐ Si ☐ No

67) Considera necesario adecuar el mensaje de acuerdo a su discapacidad? ☐ Si ☐ No

68) El mensaje estaba escrito con palabras claras y con un mensaje simple?.....

69) Entendió qué tenía que hacer?.....

70) El mensaje contenía suficiente información como para que usted supiese que el mensaje iba dirigido a usted?.....

71) Los mensajes que se emiten son fiables o se equivocan mucho?.....

72) El mensaje era preciso?.....

73) Le dió la sensación de que decía toda la verdad?.....

74) Le dió la sensación que estaban seguros de la información que daban o notaba una cierta inseguridad por parte de las instituciones que informaban?.....

75) Tenía datos completos o faltaba información?.....

76) Se informaba a tiempo real de los acontecimientos o bien la información de los mensajes iba con retraso?.....

77) Toda la información que daban las agencias coincidía o había discrepancias entre ellas?.....

Warning – Message contents:

78) Referente al contenido del mensaje, recuerda de qué informaba el mensaje?

79) Se informaba de cuánto tiempo se disponía antes de la inundación?.....

80) Se informaba sobre las dimensiones de la inundación?.....

81) El mensaje informaba de qué se tenía que hacer, qué medidas tomar?.....

82) El mensaje informaba sobre qué zonas eran seguras y de dónde se tenía que ir?.....

Response:

83) Dependiendo del tipo de alarma se debe actuar diferente?.....

84) Antes de empezar a actuar buscó la confirmación de otras fuentes? Cuáles?.....

85) Siguió las indicaciones que le indicaban los agentes?.....

86) Ante los avisos de alerta reaccionó rápidamente o se quedó bloqueado por miedo, etc.?.....

87) Fue a buscar a otra gente para que le ayudaran o lo hizo sol@?.....

88) Tuvieron que ser evacuados? ☐ Si ☐ No

89) Dónde fueron evacuados?.....

90) Fueron a casa de algún pariente? ☐ Si ☐ No

91) Fueron a refugios de emergencias? ☐ Si ☐ No

92) Cómo fueron al lugar?.....

93) Quién les llevó?.....

Emergency measures:

94) Referente a medidas de prevención, normalmente cuando va a surgir una inundación se habilitan refugios de emergencias?.....

95) Que establecimientos se usan generalmente?.....

96) Los refugios de emergencia tienen las necesidades básicas suplidas como agua, comida, sanitarios, etc.?.....

97) Referente al temas logísticos, que organización se encarga de evacuar a la población y llevarla a un sitio seguro?.....

98) Qué medio de transporte usan para transportar a los afectados?.....

Preparedness:

99) Es consciente de las consecuencias que tiene una inundación?.....

100) Cuáles son las propiedades más susceptibles a dañarse a cause de las inundaciones?

- ☐ Casa
- ☐ Cosechas
- ☐ Ganado
- ☐ Otros: ……

101) Las inundaciones le causaron daños a nivel económico?.....

102) Le dio tiempo a salvaguardar sus pertenencias en un sitio seguro antes de la inundación? ☐ Si ☐ No

103) Qué acciones tomó?

- ☐ Salvar a los miembros de la familia
- ☐ Salvaguardar al ganado
- ☐ Almacenar comida para el ganado
- ☐ Salvaguardar el pescado en estanques propios

- ☐ Salvaguardar las cosechas
- ☐ Guardar alimentos y otros medios de subsistencia
- ☐ Preparación de actividades de respuesta a las inundaciones
- ☐ Ayudar a los vecinos
- ☐ Ningún tipo de actividades de respuesta

104) En caso afirmativo, dónde?.....

105) En caso afirmativo, quién le ayudó?.....

106) En caso negativo, qué perdió o se malmetió?.....

107) Cree que es importante salvaguardar sus pertenencias?.....

108) Tiene algún seguro que le cubra los daños por inundación?.....

109) Cree que mejoraría su situación si tuviera un seguro?.....

110) Recibió alguna ayuda económica?.....

111) Cuánto tiempo recibió la ayuda económica?.....

112) Qué organización le ayudó?.....

113) Cree que las inundaciones han tenido consecuencias en su personalidad?.....

114) La inundación le causó algún daño físico o psicológico?.....

115) Perdió algún familiar?.....

116) Ha habido cambios en la familia?.....

117) Ha recibido ayuda médica?.....

118) Quién se la proporcionó?.....

119) Tiene miedo de que ocurra otra inundación?.....

120) Me podría indicar como se siente, en este momento, si piensa en el riesgo de inundación en su área?

- ☐ Aterrado
- ☐ Preocupado
- ☐ Intranquilo
- ☐ Tranquilo

121) Cree que la prevención puede mejorar la situación actual y que se reduzcan los daños causados por las inundaciones?.....

122) En su región, cuando está a punto de suceder una inundación normalmente se toman algunas acciones de prevención antes?.....

123) En caso afirmativo, qué acciones?.....

124) En caso afirmativo, quién las organiza?.....

125) Son medidas efectivas, sirven de algo?.....

126) La población participa en las medidas de preparación?.....

127) Sabe cómo se preparan otras comunidades?.....

128) Estaría interesado en recibir información a cerca de medidas de preparación ante inundaciones?.....

129) Hasta la fecha ha buscado información sobre preparación ante inundaciones?.....

130) Está interesado en tomar medidas de prevención y preparación ante inundaciones?.....

131) Considera necesario dar más importancia a la preparación ante inundaciones? ☐ Si ☐ No

132) Estaría interesado en participar activamente en el fortalecimiento del sistema actual de protección ante inundaciones?.....

Annex 3

During the stage in Bolivia, various interviews and group discussions have been carried out in order to assess the effectiveness of the current EWS in Beni, to analyze the perceptions, risk knowledge and experiences of citizens and agents, as well as, to discuss about the possible measures to strengthening the current EWS. National, regional and municipal stakeholders have been considered for the interviews and group discussions, being around 30 agents. Furthermore, after the identification of the main stakeholders, these have been interviewed several times and convened to various meetings. In order to save paper, only one interview will be shown in this MSc Thesis; however, the CD enclosed contains all interviews and group discussions carried out. It must be noted, that no all interviews and group discussions have been recorded. The list of the recorded interviews and group discussions are listed and characterized in Annex 4.

Interview 20.11.2012: Explanation of flood EWS in Santa Cruz by SEARPI

Luis Aguilera (**SEARPI**): "*A ver, Trinidad (Beni), Santa Cruz, Cochabamba, triangulo. Si observad toda esta zona está llena de ríos y el río Grande, que alimenta al Mamoré que pasa al lado de Trinidad. Esta es la cuenca alta del río Grande donde tiene parte de Cochabamba, parte de Potosí, dos cuernitos de Oruro pero Cochabamba, Potosí y Chupisaca. Entonces ésta es la cuenca alta, la cuenca media y la cuenca baja del río Grande. Tenemos otro río que es el río Piraí que se une al Yapacaní el Yapacaní se une al río Grande. Entonces tenemos estaciones hidrometeorológicas en río Grande, río Piraí, en río Yapacaní y en el río Chilo, que nosotros medimos el caudal, los niveles, la velocidad, la temperatura, la precipitación (la intensidad de precipitación) es explicándole de una forma simple, pero para que tengás una idea del orden de grandeza de*

acompañamiento a través de estaciones hidrometeorológicas. El río Grande tiene un caudal de 9000 m3/s que es algo equivalente a 30.000 m3/h, son grandes olas, es como un mar. El río Piraí es la midad como unos 20.000 m3/h, el Yapacaní es un poco más alto. Nosotros a partir de Abapó, de la junta, comenzamos a medir. Ya está programado que vamos a tener dos estaciones más en río Grande, más cuatro en el río Piraí, que hay hoy día 10 estaciones hidrometeorológicas. Tenemos nuestra central aquí, entonces hay un banco de datos del Piraí de unos 25-30 años. En el río Grande tenemos unos 20 años de acompañamiento. Esta es imagen satelital del río Grande, este es el río Piraí, el río Yapacaní. En lo que se refiere a alerta temprana, qué es lo que estamos haciendo: hasta diciembre vamos a tener ya dos estaciones de las seis en tiempo real la información vía satélite, vamos a tener toda una información que normalmente la tenemos a través de aforamientos: velocidad, caudal, precipitación, sedimentación, temperatura, humedad, etc. Todo eso va a ser en tiempo real, en una pantalla se va a uniformar todo lo que se ve en cada estación toda esta información a tiempo real. A parte de estas estaciones hidrometeorológicas, nosotros tenemos unas 40 estaciones meteorológicas distribuidas en el departamento de Santa Cruz. Este es el mapa del departamento de Santa Cruz. Tenemos distribuidas 40 estaciones meteorológicas que nosotros vamos al campo sacamos los datos, venimos o los guardamos o los interpretamos, dependiendo. Hasta el próximo año mínimo vamos a tener 6 estaciones a tiempo real y ellos automáticamente nos van a estar dando la información sin que nosotros tengamos que estar comunicándonos a través de radio con una frecuencia nuestra exclusiva, en tiempo real se va a dar. Tenemos una relación de un convenio con una organización holandesa que no recuerdo el nombre que ellos nos van a aportar US$700.000 para mejorar el SAT. Qué quiere decir ésto: o se van a hacer más estaciones o mejorar las estaciones que tenemos. Fuera de esto en nuestro POA tenemos para mejorar la informatización para el 2013. Para diciembre vamos a tener un sistema de alerta que nos informe en tiempo real, por ejemplo,

estas dos estaciones o a través de las informaciones que tenemos a través de los aforadores que automáticamente esté en el computador. Ahorita no está todo digital, pero usamos correo electrónico, pero estamos comprando un programita que va a empezar a funcionar des de diciembre donde esta información inmediatamente a través de un programa se va a comunicar con quien corresponda de alerta temprana en los municipios y con quien uno decida y defina. O sea, nosotros normalmente comunicamos, todos los años a partir de octubre mandamos notas a las alcaldías municipales y a las instituciones que están directamente relacionadas con los ríos y donde quieren indicaciones sobre la inundación y solicitamos nombres de lugares o de una forma u otra comunicarnos la alerta en un determinado momento. Entonces ya hay un proceso institucional. Con la aplicación de este programa va a ser automático este proceso, principalmente cuando esté en tiempo real los resultados de estas estaciones, no va a pasar por el hombre, va a ir directo al sistema y el sistema va a ir mandando informaciones. Usted va a recibir directamente en su celular, en el celular de cada persona que está directamente relacionada o es responsable de prevención en cada municipio. Eso ya hicimos una prueba y ya dio resultados. Si a las 8 de la mañana hay una inundación a causa de alta precipitación esta información va a salir allí. Por ejemplo el gobernador, el secretario, los canales de comunicación, etc. El río Piraí pasa por 22 municipios, el río Grande unos 27, entonces en esos 27 van a haber personas que van a recibir esta información automáticamente si que nosotros llamemos como se está haciendo actualmente. Porque entiendo que el trabajo se debe organizar a corto, medio y largo plazo. En el caso específico del Beni, se trata de un trabajo de mediano y largo plazo, no de corto. A corto plazo vamos a solucionar lo que se pueda solucionar de inmediato, pero entiendo que el próximo año ya nosotros tenemos que sentarnos, estar con ellos, visualizar si ustedes tienen el SAT de ellos, pásenoslo y nosotros lo vamos a estudiar, vamos a sugerir, les repasamos todo lo que tengamos para mejorarlo nosotros lo hacemos e

ustedes ayudan a eso. Mismo los holandeses pueden contribuir a la difusión de información para unificar el SAT que éste es uno de los problemas que tiene el Beni. SEMENA aparece allí con su alerta roja, aparece no se quién por allá, el COED por allá y al final este es el gran riesgo que hay. Eso de ahí hay que condicionarlo a una única información para que tenga credibilidad, hay que darle la sustentación, la capacitación y el equipo que necesitan. Porque yo veo importante en una acción de esta naturaleza que prácticamente toda una masa de agua de tres departamentos más Santa Cruz, cuatro todo pasa por allá, pero no para ahí. Una alerta temprana no significa actuar informando, una alerta temprana significa que el banco de datos, con las informaciones se genera un banco de datos y con ese banco de datos, yo creo que ya ha llegado el momento de pensar en obras estructurales específicas para las ciudades del Beni que no es nomás construir diques, que no es nomás hacer una Holanda en el Beni, sino que es canalizar el río Mamoré y el otro, el Beni, pero estas son acciones, como dije, de mediano y largo plazo."

Laura Basco (**DELTARES**): "*Uno de los problemas que se identificó en el taller del Beni es la rotación de personal, ustedes tienen el mismo problema acá?*"

Luis Aguilera (**SEARPI**): "*No, nosotros no tenemos este problema. Mire a este hombre lo llaman el dinosaurio (Sr. Nilo). Tiene 30 años de trabajo. Entonces, él tiene historia y él tiene la historia de una de las grandes turbiones que tuvo el río Piraí. Entonces él ya sabe que si en cierto lugar el nivel es de tanto, entonces en otro sitio más a bajo será más o menos de tanto.*"

Ricardo Caballero (**SEARPI**): "*Bueno, les voy a mostrar nuestro sistema que tenemos de SAT ante inundación. El SAT integra 16 cuencas, de las 16 cuenca nosotros monitoreamos 5 cuencas: principalmente el río Piraí, el río Grande, Ichiló, Yapacaní, Surutú. Estas cinco cuencas son importantes por la densidad*

poblacional e infraestructura e por las zonas agro-industriales. Entonces son las más estratégicas. Pero también estamos trabajando en Puerto Suarez, tenemos presencia allá, tenemos también presencia en la prefectura, en San Ignacio de Velasco, y otras muchas estaciones meteorológicas. Tenemos estaciones hidrometeorológicas y entre éstas hay hidrométricas y meteorológicas en las principales cuencas. En el río Grande tenemos en la punta, en Abapó, en Pailas, en Puerto Pacay y la Junta y tenemos proyecciones de hacer dos más: Puerto Pacheco y los Andes. En el río Piraí tenemos Bermejo, Angostura, Espejos, la central acá junto con el Puente de Urubó y cuatro ojos. También tenemos proyección de colocar dos más allá bajo. Estas estaciones que nombro son las hidrométricas. En la cuenca del río Piraí hay estaciones meteorológicas distribuidas por toda la cuenca. Después en el río Yapacaní tenemos la estación de Hierba Buena, que es la entrada de la parte de Valle Grande y el Puente de Yapacaní. Después está la estación de Palestina del río Surutú y tenemos proyección de poner una estación en la cuenca de Palestina del río Surutú y tenemos proyección de poner una estación en la cuenca de Yapacaní más. En el río Ichilo, en el puente tenemos una estación y en el río Parapetí tenemos otra estación. Todas las cuencas que están en el departamento de Santa Cruz desembocan al Mamoré, al Beni. Todas las agua confluyen en Beni. Aquí tenemos la lista de las estaciones junto con sus ubicaciones con los nombres que les he ido nombrando. El total de estaciones son 52, entre esas tenemos 5 automáticas y de las 52 tenemos 16 hidrométricas, bueno 17 porqué se ha agregado una más y el resto son estaciones meteorológicas. Entre las meteorológicas tenemos 45 que son del SEARPI, 3 son de personas particulares que nosotros monitoreamos los datos permanentemente, 2 estaciones de AASANA y 2 del SENAMHI. Estas automatizadas están para hacerlas en tiempo real, estamos en ese proceso. De momento estas automáticas acumulan la información y nosotros cada mes, cada dos meses recogemos los datos. Pero estamos en un proceso de modernización para automatizarlas éstas para recibir la información directamente.

Entonces, estamos colocando sensores, un total de seis sensores. Por lo pronto estamos instalando tres ahora y vamos a colocar otros tres en los próximos días. Son seis sensores de nivel, que es lo más fundamental para el SAT, sensores de nivel del agua. Estas automáticas las podemos volver a tiempo real porqué le conectan un módem y ya se pueden volver a tiempo real. Estamos reinstalando un teleférico en Angostura esta semana, para aforar también el turbión en Angostura y Bermejo. Estamos en la práctica de aforar en el río Chilo. Registramos los datos hidrometeorológicos de todas las estaciones, los recopilamos, los procesamos y se recogen en una base de datos. Estamos también entrando en un esquema de modernización de la base de datos porqué se nos quedó muy anticuada y la estamos modernizando. La diferencia entre registrar y recopilar: El técnico anota, entonces luego recopilamos toda esta información de todas las estaciones, venimos procesamos, hacemos una série de transformaciones y se almacena en una base de datos. Estamos en un esquema de modernizar todo, la base de datos. En cuanto a la periodicidad de las lecturas hidrometeorológicas, en tiempo seco des de abril a septiembre cada dos horas de registra la información y en periodo de lluvias que empezamos en octubre hasta marzo cada media hora se toma el registro de datos. Y si está lloviendo incluso cada 15 minutos, depende de la intensidad de acuerdo con el pronóstico de crecida que hemos evaluado, comenzamos a levantar los datos y mandar los datos, cada 15 minutos, cada 30 minutos cuando hay crecida, porque no es constante eso sino que varia. En el río Piraí puede durar horas el turbión. En el río Grande dura días, entre 15 hasta 20 días dura el turbión. Las estaciones hidrometeorológicas son las que usamos para el tema del SAT. En cuanto a las meteorológicas, recogemos los datos cada mes, se hace un recorrido para recoger toda la información que luego se almacena en la base de datos. Tenemos 8 parámetros que registramos para el proceso del SAT: observaciones milimétricas sobre el nivel del agua, es fundamental, muestreo del material en suspensión (sedimentos), se miden los caudales

en el turbión (se sacan los caudales picos), la temperatura ambiental, las precipitaciones, la medición de socavación, cuando hacemos el aforado sacamos una gráfica de socavación. El río Grande o sea si hay 5 metros, se socaban 5 metros para abajo y pasa el turbión y se vuele a nivelar. Ésto nos sirve para el cálculo de estructuras que hace el SEARPI. El río Piraí también lo hace pero el río Grande llega a 15 metros de profundidad del cauce, si no hubiera ese fenómeno se rebasaría el agua del río Grande. El Piraí hace lo mismo, se socaba y otra vez se vuele a nivelar con la arena que transporta el turbión. Y las informaciones meteorológicas para obtener los datos nos enganchamos a los satélites de Brasil, principalmente, y usamos el satélite para sondear el proceso de las nubes, de las lluvias (piratería)."

Luis Aguilera (**SEARPI**): "*Es bueno que se empiece a pensar en que podamos usar algún satélite europeo para poder hacer este sondeo meteorológico, donde se pueda tener disposición de esta información para luego poderla usarla en la alerta temprana. A través de un satélite europeo se pueda captar la información hidrológica*"

Ricardo Caballero (**SEARPI**): "*El satélite de Brasil es muy bueno, ellos hacen pronósticos precisos en su zona de sequía y de lluvia con su satélite. Claro que ellos le dan más importancia a su zona, su zona de trabajo está detallada muy minuciosamente. A nuestra zona le dan poca importancia, así que nos largan, pero así nosotros tenemos un pantallazo del recorrido de las nubes con lluvias, para darnos la idea de que dirección están tomando. Al mismo tiempo, en ese aspecto de calibrar la lluvia que está pasando en ese momento, en la cuenca alta y el pronóstico, hacemos un pronóstico de la crecida del turbión. Y de allí se activan las diferentes alertas: amarilla, naranja, roja. De acuerdo a eso, nosotros ya hacemos la alerta para no alarmar a la gente en vano porqué a veces ha llovido fuerte en la zona de acá pero no hay una crecida significante en el nivel del río. Tenemos unas tablas*

para el tránsito de crecida, eso quiere decir que el turbión recorre unos más o menos 6 km/h, eso casi es estándar, pero depende de las lluvias. Entonces nosotros sabemos cuanto tiempo tarda de una zona a otra, con la experiencia se ha confeccionado esta tabla. Por ejemplo, de la Angostura hasta acá tarda 6 horas, no fallamos ahí de avisar a la gente para que evacue antes de las seis horas, antes de que llegue el turbión. El Piraí es horas, el río Grande es días. El Grande nos da un día, dos días tenemos para disparar las alarmas, sobretodo para que la gente se ponga a buen recaudo, en ambas cuencas. De aquí se tardaban unas 12-13 días hasta el Beni, considerando nuestro turbión acá hasta que llega a Trinidad. Pero ahora, con las nuevas infraestructuras que se han construido, como los canales, este tiempo de turbión se ha reducido hasta 3-5 días. Se ha agilizado el tiempo de llegada al Beni por el hecho de que nuestros ríos están encauzados y ya no se frena tanto el río, ahora ya más rápido se van. Y esta es una observación que hicimos después de que los del Beni nos lo comunicasen. Pero más de un día para el recaudo ya es gran cosa, en el Piraí es horas."

Iván del Callejo (**Centro Agua**): "*Y ustedes monitorean el tema de deforestación?*"

Ricardo Caballero (**SEARPI**): " *Si también el tema de deforestación. Estos (mostrando en el power point) son los cálculos en el tema de temperaturas y precipitaciones. Éstos son registros de los años y éstas son las gráficas: no hay donde perderse, hay un periodo lluvioso y un periodo seco. Sobretodo en Enero y Febrero se intensifican las lluvias que dan lugar a las turbiones. A veces los turbiones llegan al Piraí y luego llegan al Grande, o sea en Enero y Febrero se intensifican los turbiones en el río Grande, hasta Marzo. Entonces con nuestra experiencia en el proceso nosotros ya sabemos que se intensifican los turbiones en esa época. El Sr. Nilo lo hace mentalmente pero nosotros lo hemos tratado de graficar y estandarizar. Y de ahí se activan las diferentes*

alertas: lo verde es normal, el amarillo es pequeña crecida, grande crecida es naranja y roja es crecida extraordinaria. Entonces cuando llegamos a rojo, a crecida extraordinaria puede ser que no se desborde el río gracias al trabajo que hace el SEARPI de contener los aludes. Sin embargo, es una crecida extraordinaria. Ha sucedido que han habido crecida extraordinarias muy fuertes y el río no se ha desbordado, por los trabajo de encauzamiento que desarrolla el SEARPI. Y esta tabla es muy útil porque no nos varía de mucho, cuando nos llegó a 3 metros en una zona de la cuenca alta, allá arriba, nosotros ya sabemos con 10 horas de anticipación la crecida aquí, será de 3,7 – 3,75 – 3,8 metros o sea que no es mucha la variación. Es a base de las estadísticas que tiene el SEARPI con los datos, que se ha hecho esta regresión. El turbión permanente puede llegar hasta 15 días. En 2011 hubo un turbión de 11 días con crecidas y bajadas del turbión pero siempre en crecida extraordinaria, es decir, en alerta roja. Pero el río no se desbordó y esas aguas van al Beni. Esta información con varios días se puede comunicar a ustedes. Pero ahora mismo no hay establecida esta comunicación. Entonces, no es costos, es cuestión de suscribirse los datos de ustedes y nosotros pasarles los datos con algunos días de antelación. Entonces, el plan de alerta temprana, que es el patrimonio del SEARPI, se activa todos los años a partir de Octubre des de la central y en todas las estaciones que están en las cuencas recibimos y copiamos la información para centralizar y procesar la información para dar los pronósticos del SAT. El director es el jefe del proceso del SAT, el director de la institución SEARPI, en forma directa. Tenemos equipos técnicos formados: A,B,C, grupos a la cabeza de nosotros para hacernos cargo por semanas por turnos a tiempo completo, día y noche, semanas enteras de turnos tenemos equipos conformados y también los equipos técnicos de los gobiernos municipales. De forma directa cada grupo está conformado por 12 personas pero indirectamente todo el SEARPI está a la voz de ese equipo y en las alcaldías municipales tenemos las listas de técnicos. Entonces nosotros mandamos una carta para que nos indiquen las

persona u oficiales que se hacen cargo del SAT, el as alcaldías. Y en sub-gobernaciones también, en las gobernaciones de las provincias también, así como el equipo del COED; nosotros aportamos e informamos del problema para que ellos (COED) ya pueden empezar a trabajar para tratar el evento. Pero nosotros somos la voz de alerta, el equipo del SEARPI. Y a las alcaldías alertamos también. "

Iván del Callejo (**Centro Agua**): *" Y el COED que función tiene?"*

Ricardo Caballero (**SEARPI**): *" El COED forma parte de la gobernación y está formado por todo un contexto de instituciones regionales: Defensa Civil, la Policía, todo lo que es salud. Que significa, que si nosotros informamos de que señores está llegando un turbión y en tantas horas va a estar en estas comunidades, hay peligro, ellos se movilizan para alertar a la gente, para colaborar en el aspecto del apoyo y retiro de la gente, ya en contexto de acción. Y nosotros estamos vigilando y al mismo tiempo atendiendo a nuestras obras que tenemos en río, que no se son caigan, en ese contexto."*

Laura Basco (**DELTARES**): *"Por lo que entiendo ustedes hacen la parte de notificación o también toman decisiones?"*

Ricardo Caballero (**SEARPI**): *"Nosotros hacemos la notificación al COED que es el organismo oficial para el proceso del movimiento, pero nosotros ya nos adelantamos a los gobiernos municipales alertando a los técnicos que están a cargo para que ya se vayan movilizando para refugiar a la gente o lo que convenga según la magnitud. Nos adelantamos con la información pero es el COED el que actúa en el hecho en sí."*

Kathia Melgar (**SEARPI**): *"Para acortar, el plan empieza en Octubre hasta Marzo. Pero nosotros ya en el mes de Septiembre enviamos una carta a los municipios que están cerca del río*

para que nos envíen el nombre de técnicos responsables para que puedan servirnos de nexo para cuando tengamos que dar una alerta. Entonces, todos los gobiernos municipales nos envían un número de al menos dos personas con celulares que van a estar pendientes las 24 horas del día para que nosotros podamos pasarles la información, ya sea al celular o correo electrónico para dar aviso. Pero más el celular."

Ricardo Caballero (**SEARPI**): " *El otro contexto es que la ventaja que tenemos nosotros es que las estaciones están en la cuenca alta y nos da tiempo para alertar a los demás que están más a bajo. Ustedes tienen un defecto, tal vez como Benianos, ustedes tienen las estaciones en los pueblos, cosa que no están alertados con antelación. Cunado están con el agua al cuello recién ustedes quieren alertar. No es el contexto así. La alerta es alerta antes de que suceda el evento. Los Benianos esto han hecho, han instalado en los pueblos y cuando el agua está hasta el cuello, gritan.*"

Iván del Callejo (**Centro Agua**): "*Ellos dependen de la información que ustedes generen*".

Ricardo Caballero (**SEARPI**): "*Exacto. Otra opción es colocar estaciones más arriba para tener suficientes horas para avisar y alertar, que lo que se quiere es eso. El SAT empieza aquí en Santa Cruz. Dado que influye el río Grande tiene que haber un contacto directo y también de lo que viene de la Paz y del Chapare que son los más importantes. Ahora el monitoreo lo hacemos las 24 horas del día, evaluamos los datos hidrometeorológicos en cada momento, evaluamos las crecidas porqué es también un estudio es el pronóstico de crecidas según la clasificación de las crecidas. Puede ser una crecida que se diluye, pero luego nosotros tenemos que hacer un análisis y ver si esa crecida tiende a crecer y a crecer del turbión. Si la lluvia sigue aumentando a nosotros se nos va creciendo el nivel. Nosotros recién nos tranquilizamos cuando los niveles bajan, pero tenemos que ver si sigue lloviendo a*

arriba para que pueda pasar que vuelva a retomar la crecida del río. Éste es nuestro juego para la clasificación de crecidas que al final estamos haciendo un pronóstico de las crecidas del río."

Iván del Callejo (**Centro Agua**): "*Para esto ustedes utilizan alguna herramienta para la clasificación o es más a partir de la experiencia de él (Sr. Nilo)?"*

Ricardo Caballero (**SEARPI**): "*Es un análisis directo, no se basa en la modelación, estamos haciendo una consultoría hidráulica e hidrológica, estamos en ese contexto de trabajo, pero aún no nos han expuesto los resultados todavía. La clasificación es casi de carácter directo basándose en la precipitación y en los niveles del agua, en la medición que se va haciendo. Con gente que está allí de manera permanente que nos informa de los niveles y de las precipitaciones. La transmisión de información es casi a tiempo real, cada hora o media hora según el evento y el periodo. Entonces antes de que pase un evento se evalúa la información. Con el porcentaje de lluvia en una determinada zona ya sabemos el porcentaje de escurrimiento en la zona. Con la información ya sabemos el tránsito de la crecida, a qué hora va a llegar a una determinada zona y así manejamos. Primero empezamos con las lluvias. Nosotros nos basamos mucho en la información de las cuencas alta y media, pero a veces nos llueve aquí, pero no nos hace mucha crecida del río, no es mucho el efecto. Aquí ha llovido 230 mm el otro día. En el río Piraí no pasaba nada, en cambio aquí estábamos saturados. Una vez el SEARPI hace este proceso, el análisis, etc. Entonces la información pasa al COED y el SEARPI acompaña con información permanente de los niveles e inspeccionando sus defensivos del río. A parte de la información del satélite brasileño, también es fundamental la información meteorológica del SENAMHI, que ya nos da una idea en que zona va a llover. De algo nos sirve para visualizar que va a pasar hasta 4 días de pronóstico. Es el SENAMHI regional porque tenemos compromisos. Pero igualmente en la página web*

del SENAMHI nacional se puede entrar y hay también mucha información. También nosotros usamos la información de AASANA que también nos sirve. AASANA genera entre 15 y 20 días de pronósticos y aciertan, nos sirve de pauta. Cuanto más largo es el período es más inseguro. Entre 3 y 5 días es ideal, a partir de ahí ya no es muy fiable."

Ivan del Callejo (**Centro Agua**): *"El ingeniero Aguilar decía que van a digitalizar el tema de la alerta, la digitalización de los caudales, etc. Ésta automatización se basa en hacer éste proceso más rápido?*"

Ricardo Caballero (**SEARPI**): "*La automatización más va con el contexto de la comunicación en tiempo real, o sea, usted está mirando a tiempo real en una pantalla lo que está pasando allá. Pero después los datos van a ser los mismos.*"

Kathia Melgar (**SEARPI**): "*Y permite que los datos que reporta nuestro aforador cada hora o cada dos horas nos sean disponibles a través de este sistema.*"

Ricardo Caballero (**SEARPI**): "*Ahora bien, la cuestión de la consola que mide la precipitación, eso también se nos va a mandar directo. Ésa es la automatización, va referido a tiempo real y que la máquina lo registre. En cambio es visual lo que hemos venido llevando. A parte, tenemos perfiles longitudinales de los ríos. El Piraí en comparación con el río Grane tiene más pendiente. Todos los ríos tienen sus niveles ya calibrados con datos o de manera gráfica y se hace un boletín que se publica con los datos básicos que incorpora los datos de la crecida, la precipitación y el estado climático. Nosotros investigamos las condiciones meteorológicas de arriba de Oruro, Potosí y de Cochabamba gracias a los datos del SENAMHI y así sabemos más o menos cuando va a tardar en llegar a Santa Cruz. Y eso deberían hacer los Benianos, venir a sondear Santa Cruz con el SENAMHI. Esa conexión entre Beni y Santa Cruz debería haber, ya habíamos hablado unos años atrás*

que fuimos a exponer yo y el director y hablamos de este tema pero nunca se manifestaron. Aquí (refiriéndose al power point) está el cronograma con los diferentes grupos de trabajo junto con las autoridades y el personal de SEARPI que tienen que estar atentos. Y esto ya son órdenes del director, pobre del que no conteste al celular en época de lluvias. No le paga el mes. Esta es la carta que mandamos a los municipios pidiendo que nos manden los nombres de al menos dos personas para la SAT. Lo mandamos en Octubre, con antelación, y ahora (finales de Noviembre) ya nos están empezando a llegar"

Ivan del Callejo (**Centro Agua**): *"Uno de los problemas que hay en Trinidad y en muchas partes del país es la rotación de personal en los municipios. No hay una persona responsable que permanezca mucho tiempo en el mismo puesto de trabajo, las UGR son muy débiles, no hay una persona responsable, etc.*"

Ricardo Caballero (**SEARPI**): "*Yo creo que no hay que entrar en ese tema de preocupación, ocurre lo mismo aquí. Entonces no nos preocupa eso, la cuestión es que nos manden una lista aunque la cambien al cabo de un tiempo. No necesitan días para mandar una lista, es cuestión de horas. La que tiene que estar atenta es la institución al cargo del sistema de alerta. Ellos duermen en sus laureles.*

Ivan del Callejo (**Centro Agua**): *"Qué capacidades tendrían que tener los municipios?"*

Ricardo Caballero (**SEARPI**): "*Cada municipio ha ido tomando un esquema de seriedad algunas como Yapacaní está siendo apoyada por otras instituciones como Acción contra el Hambre. A nosotros nos interesa mucho que allí se consolide un sistema que tenga la capacidad para ir y correr a avisar a sus comunidades, para ir a sacar la gente del lugar, mejorar el tema de comunicación. Nos interesa que los municipios tuvieran eso, pero básicamente a nosotros nos importa que haya una persona que logre avisar a las personas aguas abajo. Ellos ya*

saben que zonas son susceptibles a inundaciones o de problemas. Cada municipio tiene su ordenamiento territorial y tienen sus mapas de riesgos y vulnerabilidad. Entonces ellos ya pueden actuar. Entonces, depende mucho de la dinámica del alcalde y sus técnicos. Lo importante es tener una persona de contacto para llamar y por último los alcaldes, cuando no tienen técnicos, al alcalde es al que llamamos. En ese caso es cuando el municipio es afectado por la inundación, pero hay otros que son de la parte alta que no les afecta así que hay algunos que no se molestan en enviarnos la lista. Entonces el detalle es que ellos tienen problemas de sequía o incendios así que también se ven afectados. Entonces ellos también tienen su SAT, levemente tienen. Ésta es nuestra carta que les mandamos y aquí está la lista de las autoridades y de los cabañeros, que son los que sacan áridos del río y están permanentemente trabajando en el cauce del río, duermen allá. Y nosotros tenemos a sus principales dirigentes con sus celulares y les llamamos para avisarles y para que salgan. Porqué alguna vez se han dejado atrapar porqué beben y se duermen y no se enteran del aviso. Pero lo ideal sería que nosotros, a nosotros nos falta un sistema de sirena o de algo así que haya, apretar un botón y que se encienda un sirena allá para alertar. Algún día llegaremos a conseguir eso. Necesitamos llegar, porqué hay gente que vive en el río haciendo constantemente actividades es su fuente de trabajo; y los bañistas también."

Sr. Nilo (**SEARPI**): "*En otros países, como en la Argentina, son los municipios los que se encargan de ayudar e implementar el SAT y lo que también hay personas que están capacitadas para ayudar a la gente que está afectada, en las carreteras o en las mismas playas. Lo que pasa es que en las mismas playas hay gente que realiza sus actividades. Pero gracias a Dios no nos faltan muchas cosas porqué tenemos un periodo de tiempo de 4-6 horas cuando hay el evento. Es muy necesario tener dispositivos móbiles que vayan transmitiendo la alerta*."

Ricardo Caballero (**SEARPI**): "*Porqué la gente es inconsecuente, hasta que no ven el agua no actúan. Incluso tienen maquinaria, motores allí que dragan y los tipos ven el turbión y salen a la orilla y justo cuando el turbión viene entran al agua para recoger su maquinaria y se dejan agarrar. Y esos son los que se dejan agarrar, entran a sacar el motor justo cuando ven venir el turbión. O sea es un problema social, de capacitación. Es muy riesgos para nosotros. Si tuviésemos una sirena o así sería muy útil para avisar a la gente para que salga del río. Ésta es la lista para que la gente de las instituciones manden su correo para luego avisar a las autoridades. Entonces éste es nuestro sistema de alerta SAT, es un poco criollo, lo digo porqué aún nos falta automatizar. El director nos está exigiendo que nos automaticemos, pero nos está costando porqué incluso la compra de equipos cuesta. O sea hay gente que vende equipos pero son equipos domésticos, que no son equipos profesionales. Y los equipos profesionales cuestan un ojo a la cara. Estamos comprando un equipo de Molinex por 140.000 bolivianos que es sensor nada mas del agua y el software nos cuesta 95.000 bolivianos. Solamente el sensor del agua. Y otro equipo en 12.500 bolivianos, y el mismo equipo que estamos comprando de otra institución para ver porqué esa diferencia de precio abismal. Pero ya más o menos ahora viendo, el de 140.000 bolivianos tiene una capacidad de 35 metros de distancia. Éste otro sólo 9 metros sensorea. Entonces por ahí va la cosa. Estamos pues en un proceso de modernización, queremos modernizarnos lo antes posible porqué tenemos personal trabajando en el campo con fuerza humana, con personal humano y hemos ido a mucho congresos a explicar y les ha gustado el proceso pero es con fuerza humana.*"

Ivan del Callejo (**Centro Agua**): "Con *cuánta gente cuenta el SEARPI en total?*"

Sr. Nilo (**SEARPI**): "*En la parte hidrológica contando tanto los que están en el campo, como los que están aquí en la central*

son entre 28 y 30 personas. A parte hay la unidad de obras, etc. Nosotros nos encontramos dentro de la unidad de manejo integral de cuencas.

Ricardo Caballero (**SEARPI**): "*Nosotros recibimos el dinero de la gobernación. Tenemos financiamiento básicamente de la gobernación pero también hemos conseguido captar fondos de organismos internacionales, de la CAP, del Banco Mundial, etc. Ahorita el Banco Mundial están loquitos para ayudarnos no el sistema de alerta temprana. Estamos consiguiendo unos US$14.000.000 del Banco Mundial para el SAT en equipos, en consultorías. El Banco Mundial va ha hacer muchas consultorías para evaluar los procesos que venimos haciendo, por ejemplo, se va ha hacer una consultoría para evaluar todos los equipos que tenemos en las estaciones, otra consultoría será para mejorar los equipos que están. Otra consultoría es para el SAT, en el tema de la comunicación hacia a bajo hacia arriba. Tendrían que haber empezado en Octubre, Noviembre los procesos, pero yo creo que en Enero, Febrero ya van a tirar con ganas en los procesos.*"

Ivan del Calejo (**Centro Agua**): "Y esto es como crédito de la gobernación?"

Ricardo Caballero (**SEARPI**): "*En el caso del Banco Mundial parece que fuera préstamo al gobierno. Pero ellos tienen la potestad de dirigirlo todo. Ellos escogen los términos de referencia, ellos ponen las condiciones. Ellos son los que deciden.*"

...

Laura Basco (**DELTARES**): "*Se puede decir que ustedes están bien organizados, incluso a nivel externos con las municipalidades.*"

Ricardo Caballero (**SEARPI**): "*Cuesta hacer cumplir a las municipalidades.*"

Ivan del Callejo (**Centro Agua**): "*Ustedes mencionaban dos estaciones meteorológicas de AASANA, dos de SENAMHI, 3 de privados, etc. la mayor parte de las estaciones son de ustedes propias. Pero hay una red más grande que ésta que tal vez se podría alimentar a este sistema.*"

Ricardo Caballero (**SEARPI**): "*Porqué nosotros sabe lo que hacemos, cuando nos referimos a SENAMHI nos referimos a las estaciones de Viru-Viru y al 'Compillo', digamos a estaciones conocidas. Y cuando decimos otras son la de la universidad otras dos de personas particulares, empresarios que nos prestan las información de sus estaciones pero son meteorológicas. Ahora bien, qué pasa? En el SENAMHI uno puede entrar en su página web y sondear las estaciones, qué está ocurriendo en las estaciones de ellos. Generalmente, no son datos a tiempo real, o sea, los datos de ayer, los reportan hoy día o mañana. Ese es el único defecto. Pero uno se entra mira y puede saber si por ejemplo llovió en Cochabamba, cuando va a llover auí y en cuanto tiempo. Entonces uno puede sondear los datos del SENAMHI sin necesidad de tener relación directa con ellos. Digamos que ellos son... no les van a dar sus códigos para entrar ni nada. Sólo a través de su página web, incluso yo he conseguido datos históricos suyos.*"

Sr. Nilo (**SEARPI**): "*Una de las debilidades que tiene la región del Beni, es que ellos están escasos de estaciones. Nosotros tenemos la ventaja es que tenemos más estaciones y podemos manejar las estaciones. Para tener un SAT efectivo hay que tener estaciones, pero para tener estaciones hay que tener equipos y para tener equipos hay que tener personal capacitado. Si tenemos personal capacitado, tenemos buena información y si tenemos buena información, tenemos un buen SAT. Y eso es lo que le falta al Beni.* "

Ricardo Caballero (**SEARPI**): *"Otro detalle que yo veo es que la alerta temprana tiene que estar a cargo de una institución, me refiero al contexto de la evaluación del fenómeno. Pero si todos quieren opinar, quieren calibrar el río, se mete la alcaldía, se mete la gobernación, se va a meter otra gente, etc. y al final la población a quién va ha hacer caso?."*

Kathia Melgar (**SEARPI**): *"De todas maneras tal y como decía el Sr. Nilo, nosotros también tenemos bastantes deficiencias en nuestras estaciones para monitorear el comportamiento de toda la cuenca. En este documento de 2010, estamos sacando el de 2011, ahí ustedes pueden ver en un diagrama hasta donde van nuestras estaciones hidrométricas. Si ustedes analizan acá, hay un análisis que se ha hecho a un evento de crecida el mayor evento. Fíjese hasta donde monitoreamos la cuenca y cual es nuestra debilidad. Por ejemplo, este año ya hemos instalado una en 4 Ojos, pero necesitamos ver el comportamiento hasta el final, ver cómo sale de la cuenca esa agua porqué esta agua alimenta al Mamoré. En la cuenca del río Grande también, tenemos una carencia porqué nos gustaría diversificar mas para conocer. Y todo esta zona es para nosotros también desconocido, entonces nos gustaría mucho más diversificar."*

Laura Basco (**DELTARES**): *"Este proyecto con una compañía holandesa, es para estas estaciones, para fortalecer la red de monitoreo?"*

Kathia Melgar (**SEARPI**): *"Si, nos llegó este año, hará un mes, pues por sorpresa de que podían ellos financiarnos y pues, hemos presentado un proyecto por poco más de 700.000 euros que nos van permitir diversificar un poco más y mejorar nuestro SAT, que nuestro SAT es alerta temprana para el Beni. Entonces no es sólo un proyecto regional, sino a nivel nacional."*

...

Kathia Melgar (**SEARPI**): *" Ustedes pueden ver en nuestra página web por ejemplo los boletines, no es tiempo real, pero ahorita*

por ejemplo ya salió el de las 10 de la mañana. Pero hasta que taipean los datos, hasta que los suben, hasta que el revisor revisa la información, etc. conlleva una hora, pero es casi casi a tiempo real. Para algún municipio que quiera monitorear sus situación, puede entrar en la página web del SEARPI y puede ver los reporte. Es libre. Lo que nosotros queremos hacer ahorita es que el nivel que esté en este momento en Angostura que lo veamos nosotros pero que eso todavía no se comparta con todos los actores. Porqué la información cruda puede provocar algún pánico en la población. Porqué si ustedes en la página van a poder ver la clasificación de colores que les mostró el ingeniero para un pequeña, grande crecida. Imagínese la persona que vea que ya des de hace dos horas ya sus puntito están creciendo y están en alerta roja, puede causar un tema de pánico. Pero en cambio nosotros vemos y decimos cómo está en la cuenca alta si ya paró de llover entonces ni siquiera reportamos que ni hay alerta naranja ni ningún tipo de alerta. Simplemente llamamos y decimos que tengan precaución porqué en dos horas llega una subida del nivel pero en dos horas pasa. Porqué hay el tema de los dragueros que hacen la extracción de áridos en el río, que son ellos los que nos llaman también a nosotros, que ven que sube el nivel del río y nos llaman y nos preguntan si está lloviendo en la cuenca alta. O sea nosotros estamos en ese trabajo de analizar qué pasa. Nuestro sistema de basa sobretodo en el factor humano, pero eso queremos automatizarlo, estamos comprando unos equipos. Porqué hasta ahora era todo muy manual. Incluso nuestro sistema de comunicación es por radio. Pero hasta ahora funciona."

Annex 4

1. Interview with SEARPI on the 20.11.2012.
2. Interview with SEARPI on the 20.11.2012
3. Interview with SENAMHI Santa Cruz 20.11.2012
4. Interview with SENAMHI Santa Cruz 20.11.2012
5. Interview with FAN 20.11.2012
6. Interview with SEARPI on the 22.11.2012
7. Interview with SEARPI on the 22.11.2012
8. Interview with SENAMHI Beni on the 27.11.2012
9. Interview with SENAMHI Beni on the 27.11.2012
10. Interview with DGR/COED Beni on the 27.11.2012
11. Interview with FUNDEPCO on the 27.11.2012
12. Interview with UGR Santa Ana del Yacuma on the 30.11.2012
13. Interview with UGR San Ignacio de Moxos on the 03.12.2012
14. Interview with UGR San Ignacio de Moxos on the 03.12.2012
15. Interview with SENAMHI Cochabamba on the 05.12.2012
16. Group discussion with VRHR, DGR Beni, UGR San Ignacio de Moxos, UGR Santa Ana del Yacuma and GAM Loreto on the 26.02.2013
17. Group discussion with VRHR, DGR Beni, UGR San Ignacio de Moxos, UGR Santa Ana del Yacuma and GAM Loreto on the 26.02.2013
18. Interview with a woman who live in Santa Ana del Yacuma on the 02.12.2012
19. Interview with a student who lives in Loreto on the 01.04.2013
20. Interview with a farmer who lives in Loreto on the 01.04.2013
21. Interview with some teachers who live in Loreto on the 01.04.2013

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Acronyms

A.A.S.A.N.A: Administración de Aeropuertos y Servicios Auxiliares a la Navegación Aérea

B.I.D.: Banco Iberamericano de Desarrollo

C.I.D.D.E.B.E.N.I: Centro de Investigación y Documentación para el Desarrollo del Beni (ONG)

C.I.P.C.A: Centro de Investigación y Promoción del Campesinado

C.O.E.D.Beni: Centro de Operaciones de Emergencias Departamental

C.P.I.B: Central de Pueblos Indígenas del Beni

D.G.R.: Dirección de la Gestión de Riesgos de la Gobernación

D.O.T.: Dirección de Ordenamiento Territorial de G.A.D. del Beni

E.N.D.E.: Empresa Nacional de Electricidad

E.P.A.R.U: Equipo de Pastoral Rural

E.W.S: Early Warning System

F.A.N.: Fundación Amigos de la Naturaleza

F.U.N.D.E.P.C.O.: Fundación para el Desarrollo Participativo Comunitario

G.A.D. Beni: Gobierno Autónomo Departamental del Beni

G.A.M.: Gobierno Autónomo Municipal

I.H.H.: Instituto de Hidráulica e Hidrología

M.M.A.y A.: Ministerio de Medio Ambiente y Agua

P.M.A.: Programa Mundial de Alimentos de la ONU

P.N.C.: Plan Nacional de Cuencas

S.A.T: Sistema de Alerta Temprana (EWS)

S.D.C. de Cochabamba: Servicio Departamental de Cuencas de Cochabamba

S.E.A.R.P.I.: Servicio de Encruzamiento de las Aguas y regularización del río Piraí

S.E.M.E.N.A.: Servicio al Mejoramiento de la Navegabilidad Amazónica

S.E.N.A.M.H.I.: Servicio Nacional de Meteorología e Hidrología

S.N.H.N.: Servicio Nacional de Hidrografía Naval

U.A.B.: Universidad Autónoma del Beni

U.C.R.: Unidad de Contigencia Rural del MDRyT (Ministerio de Desarrollo Rural y Tierras) enfocado al sector agropecuario

U.G.R.: Unidad de Gestión de Riesgos de los municipios

V.C.A.: Programa Vivir con el Agua

V.I.D.E.C.I.: Ministerio de Defensa Civil

V.R.H.R.: Viceministerio de Recursos Hídricos y Riego

Key terms[75]

Disaster: A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental loss which exceed the ability of the affected community or society to cope using its own resources.

Disaster Risk: The potential disaster losses, in in terms of lives, health status, livelihoods, assets and services, which could occur in a particular community or a society over some specified future time period.

Disaster risk reduction: Conceptual framework of elements considered as having the potential for minimizing vulnerabilities and disaster risks throughout a society, or to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development.

Early Warning: The provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.

Forecast: Definite statement or statistical estimate of the likely occurrence of a future event or conditions for a specific area.

Hazard: A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can have various origins: natural (geological, hydrometeorological and biological) or can be induced by human processes (environmental degradation

[75] UNISDR, 2009

and technological hazards). They can be single, sequential or combined in their origin and effects.

Mitigation: Structural and non-structural measures undertaken to limit the adverse impact of natural hazards, environmental degradation and technological hazards.

Preparedness: Activities and measures taken in advance to ensure effective response to the impact of hazards, including the issuance of timely and effective early warnings and the temporary evacuation of people and property from threatened locations.

Prevention: Activities which provide outright avoidance of the adverse impacts of hazards and provide the means to minimize related environmental, technological and biological disasters.

Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions.

Response: The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Risk: The probability of harmful consequences, or expected loses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interaction between natural or human-induced hazards and vulnerable conditions.

Vulnerability: The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

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